Number 24 Series 1926

UNITED STATES DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
In Cooperation with the Colorado Agricultural Experiment Station

SOIL SURVEY
OF
THE ARKANSAS VALLEY AREA COLORADO

BY

A. T. SWEET, U. S. Department of Agriculture, in Charge
and WAYNE INMAN, Colorado Agricultural Experiment Station

Beginning with the 1923 Series, Soil Survey Reports have been issued separately. The reports of the individual areas are sent to libraries as soon as they are available and should be filed, preserved, and ultimately bound to take the place of the bound volumes of the Field Operations which were formerly supplied by the department. The reports for each year are consecutively numbered, the last report for a particular year bearing the conspicuous notice: "This number is the last Soil Survey Report for the Year 192–."

For sale by the Superintendent of Documents, Washington, D. C. - - - - Price 50 cents

BUREAU OF CHEMISTRY AND SOILS

HENRY G. KNIGHT, *Chief*
A. G. McCALL, *Chief, Soil Investigations*
SYDNEY FRISSELL, *Editor in Chief*

SOIL SURVEY

CURTIS F. MARBUT, *in Charge*

COOPERATION

COLORADO AGRICULTURAL EXPERIMENT STATION
C. P. GILLETTE, *Director*

CONTENTS

SOIL SURVEY OF THE ARKANSAS VALLEY AREA, COLORADO

By A. T. SWEET, United States Department of Agriculture, in Charge, and WAYNE INMAN, Colorado Agricultural Experiment Station

AREA SURVEYED

The Arkansas Valley area is in southeastern Colorado, extending from the Kansas-Colorado State line westward to Pueblo, a distance of approximately 145 miles, and including the lands of the Arkansas Valley [1] proper and adjacent irrigated uplands. Two small detached additional areas have been included, one extending along the river from Florence to the lower slope of the Rocky Mountains at Canon City and the other occupying a small area on the high mesa northeast of Florence.

For convenience in mapping, some areas not under irrigation have been included and small irrigated areas, where the time and expense necessary to map them were considered too great, have been omitted. The total area covered by this survey is 1,112 square miles, or 711,680 acres.

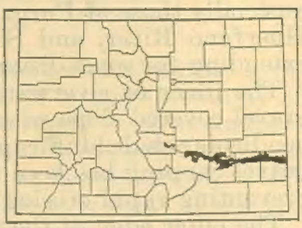


FIGURE 1.—Sketch map showing location of the Arkansas Valley area, Colo.

The western part of the Great Plains region, in which this area lies, slopes from the foot of the Rocky Mountains eastward beyond the limits of the area. Its elevation at Canon City, 185 miles west of the Kansas State line, is approximately 5,333 feet, at Pueblo 4,700 feet, and at Holly, near the Kansas State line, 3,400 feet above sea level.

Into this sloping plain Arkansas River has cut a broad but comparatively shallow valley, terminating on the west in steep mountain slopes. This valley is bordered by steep rocky bluffs, high mesas, and terrace slopes in the upper part; by slopes of lower-lying mesas, hills, low river bluffs, and terraces in the central part; and by more nearly level undulating country only slightly higher than the river valley in the lower part. The lower part of the valley, considering the region in detail, consists of an undulating upland sloping gradually toward the river. (Pl. 1, A.)

The transition from this gradually sloping and undulating upland to river terraces and long gradual slopes formed in part by river erosion is approximately in the vicinity of Kreybill, about 3 miles east of Fort Lyon. Here the irrigated land on the north side of the river, extending westward to the vicinity of La Junta, consists of a gently southward-sloping plain. Here the river at one time seems to have swung far north of its present course, but as its channel was eroded more deeply it moved southward, leaving this long slope intermediate between river terrace and upland. Near its eastern

[1] The name "Arkansas Valley," as popularly used, applies not only to the valley proper, the flood plain, and river benches, but also to considerable upland within the Arkansas River drainage basin, parts of which are irrigated.

extension this slope along the side toward the river lies from 50 to 75 feet above the flood plain and rises toward the north at the rate of about 75 feet a mile. It merges into more uneven uplands along the line of the Fort Lyon Canal. West of Adobe Creek its slope becomes more gradual and it lies at a lower elevation above the river, merging into the river flood plain near La Junta.

Along the south side of the river, beginning at La Junta and extending westward beyond the State farm near Pueblo, is a series of river terraces or benches ranging in width from less than 1 to more than 3 miles and having a general but slight slope toward the river and down the valley. A similar old river terrace borders the river on the south at Canon City. These terraces are lowest at Rocky Ford, where the elevation above the river flood plain is less than 25 feet. They gradually rise higher above the flood plain toward the west, being nearly 100 feet above it at Pueblo and more than 150 feet at Canon City. At the entrance of the larger tributary streams, especially those of Purgatoire River, Timpas Creek, Apishapa Creek, Huerfano River, and St. Charles River, the terraces broaden out, extending for some distance along the stream valleys.

The inner or riverward edge of the terraces is marked by a steep gravel-covered slope where the terraces are low and by a nearly perpendicular shale bluff capped with gravel where they are high. This gravel capping has been the principal factor in terrace preservation, preventing rapid erosion of the soft underlying shale.

The outer edge of the terraces merges gradually into the adjacent uplands. From La Junta westward to Pueblo these slopes along the south side of the terraces are in most places not too steep for cultivation. In many places near the top of the slopes there is a thin capping of very old stream gravel with a highly developed layer of lime accumulation seen as a white coating on the gravel. Long-continued erosion has, however, given rise to gravel-capped ridges and rounded knobs, merging into more level uplands farther back from the river. The same gravel capping occurs on lower hills and ridges toward the eastern limits of the area. In a number of places, especially near the entrance to the river valley of the larger tributaries, the river seems gradually to have moved laterally as it has worked deeper, leaving long smooth slopes rather than level terraces. Slopes of this kind border the river flood plain most of the way between Apishapa Creek and Huerfano River.

From a short distance west of Pueblo to within about 2 miles of Florence, Arkansas River flows through a narrow shut-in valley with steep and, in places, nearly perpendicular walls of shale and limestone about 200 feet high. Near Florence it opens out into a broader valley which extends to the foot of the mountain slope at Canon City. Near its upper extension it broadens into a small shale valley north and east of Canon City on the north side and is bordered by a high river terrace on the south side.

North and east of Florence on a broad gently southward-sloping mesa 200 feet above the river flood plain a small area surrounding the village of Penrose is irrigated from storage reservoirs in the mountains to the north.

Early settlements in the Arkansas Valley began about 1865. The first large irrigation ditch was constructed in 1874. From that time settlement was rapid. At present all land for which irrigation

water is available is under cultivation and a large part of it is farmed intensively. Considerable adjacent areas are farmed without irrigation. The mapped area includes the most densely populated and intensively farmed parts of six counties, Prowers, Bent, Otero, Crowley, Pueblo, and Fremont. Towns are distributed along the valley at rather regular intervals, with numerous other smaller towns and villages between.

The Atchison, Topeka & Santa Fe, Missouri Pacific, and Denver & Rio Grande Western railroads furnish good shipping facilities for all parts of this region.

Good highways traverse the valley on one side and for part of the distance on both sides, and all parts of the region are reached by good roads.

Many products of the Arkansas Valley are sold on practically all markets of the United States. Large quantities of garden truck, fruit, and poultry are sold locally and in near-by towns.

CLIMATE

The Arkansas Valley, on account of its high elevation, has a rare atmosphere. The pressure at Denver, which is approximately the same as at Canon City, is only 12.2 pounds a square inch as compared with 14.7 pounds a square inch at sea level. Plants grow more rapidly and seeds mature more quickly than at lower altitudes. The frost-free season, therefore, is not comparable to seasons of the same number of days at lower altitudes.

Tables 1 and 2, based on data of the Weather Bureau, give the normal monthly, seasonal, and annual temperature and precipitation at Lamar, in Prowers County, and at Canon City, in Fremont County.

TABLE 1.—*Normal monthly, seasonal, and annual temperature and precipitation at Lamar*

[Elevation, 3,592 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1910)	Total amount for the wettest year (1915)	Snow, average depth
	°F.	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	32.2	79	−17	0.70	(1)	0.27	4.6
January	30.7	78	−17	.28	.20	.27	2.8
February	33.4	82	−30	.61	.70	1.17	7.1
Winter	32.1	82	−30	1.59	.90	1.71	14.5
March	43.9	94	−13	.82	0	1.96	4.0
April	53.3	95	10	1.85	1.31	3.56	3.2
May	62.7	100	20	2.04	2.58	4.47	(1)
Spring	53.3	100	−13	4.71	3.89	9.99	7.2
June	73.2	107	33	2.09	.54	5.38	0
July	77.9	109	42	2.66	1.76	2.68	0
August	76.8	107	44	2.00	.91	3.16	0
Summer	76.0	109	33	6.75	3.21	11.22	0
September	69.8	106	27	1.19	.06	1.06	(1)
October	54.9	97	8	.86	0	0	1.1
November	42.4	83	−4	.41	.10	(1)	2.0
Fall	55.7	106	−4	2.46	.16	1.06	3.1
Year	54.2	109	−30	15.51	8.16	23.98	24.8

[1] Trace.

TABLE 2.—*Normal monthly, seasonal, and annual temperature and precipitation at Canon City*

[Elevation, 5,343 feet]

Month	Temperature			Precipitation			
	Mean	Absolute maximum	Absolute minimum	Mean	Total amount for the driest year (1893)	Total amount for the wettest year (1919)	Snow, average depth
	°*F.*	°*F.*	°*F.*	*Inches*	*Inches*	*Inches*	*Inches*
December	35.9	76	−25	0.54	0.04	0.92	7.2
January	35.3	75	−24	.37	.10	.16	4.1
February	35.2	76	−30	.59	.10	.95	8.1
Winter	35.5	76	−30	1.50	.24	2.03	19.4
March	42.9	83	−6	.81	(1)	2.15	6.0
April	50.0	87	1	1.67	.15	1.54	4.9
May	57.4	94	23	1.60	.85	1.10	.3
Spring	50.1	94	−6	4.08	1.00	4.79	11.2
June	66.1	102	31	1.14	.03	.98	(1)
July	72.9	104	35	1.86	2.79	2.07	0
August	72.3	102	35	1.88	1.08	3.53	0
Summer	70.4	104	31	4.88	3.90	6.58	(1)
September	64.3	100	25	.82	0	2.75	.3
October	53.1	89	2	.84	0	.75	2.7
November	43.4	89	−13	.52	(1)	2.01	4.5
Fall	53.6	100	−13	2.18	(1)	5.51	7.5
Year	52.4	104	−30	12.64	5.14	18.91	38.1

1 Trace.

The normal frost-free season at Lamar is 167 days, the average date of the latest killing frost being April 25 and of the earliest October 9. The latest recorded killing frost was on May 16 and the earliest on September 17. At Canon City the average date of the latest and earliest killing frosts, respectively, are May 1 and October 11, and the latest and earliest recorded were on June 2 and September 17, respectively. Thus, the normal frost-free season at Canon City is 163 days.

Climatic conditions which influence crop production to the greatest extent in this region are the following: (1) Snowfall in the mountains, which supplies most of the water for irrigation; (2) rainfall during the growing season, to supplement irrigation; (3) late spring and early fall frosts and freezes, both of which at times cause injury; (4) hail, by which serious damage is sometimes caused, especially in the region near the mountains; and (5) torrential rains causing damage to irrigation ditches, roads, and cultivated fields.

Dry air and strong winds are also important factors both in soil development and in crop production. On account of the high rate of evaporation, considerable moisture is required to produce a crop. Strong winds and beating rains cause crusting, and blowing of sand frequently causes damage to young plants.

As a whole the climate is well suited to the kind of agriculture carried on. All crops, except irrigated alfalfa, mature large quantities of seed of good quality, and fruits are well colored and highly flavored.

SOIL SERIES AND TYPES

In soil classification, all soils are classed in major groups or series, largely on the basis of the character of the soil profile. The series may be further divided into soil types, differentiated on the basis of the texture of the surface soil; that is, the proportion of different-sized particles present. In this survey, 32 soil types and 16 phases of types, representing 12 soil series, and 1 miscellaneous class of material, river wash, are mapped. A brief description of the general characteristics of the soil series follows.

Soils of the Prowers series have brown or dark-brown surface soils and lighter uniformly brown subsoils. The substratum consists of light-textured clay loam, silt loam, or very fine sandy loam. The loam, clay loam with a poorly drained phase, fine sand, and loamy fine sand with a heavy phase, members of the Prowers series, are mapped.

Soils of the Fort Lyon series are brown or reddish brown. Sufficient sand and coarse sand are present in the subsoil to give it a rough feel. There are two subsoil layers, one heavy and reddish brown and the other nearly white and very rich in lime. The deep substratum is of lighter texture. The clay loam with a shallow phase, loam with a level phase and a shallow phase, sandy loam, and gravelly loam members of the Fort Lyon series are mapped.

The Otero soils have brown or reddish-brown surface soils. There is an accumulation of lime in well-defined spots in the upper part of the subsoil, and the deep subsoil consists of open but sticky sandy clay. There is a fairly well-developed adobe structure in the surface and upper part of the subsoil horizons. The lime accumulation of the subsoil is nearer the surface than in either the Prowers or Fort Lyon soils and is heavier than in the Prowers but not so heavy as in the Fort Lyon. These soils contain enough medium and coarse sand to give them a somewhat rough feel. The loamy sand, sandy loam with a slope phase, and clay loam with a poorly drained phase, soils of the Otero series have been mapped.

Soils of the Rocky Ford series have dark-brown finely granular surface layers, an inch or two thick, under which is a brown or reddish-brown loamy layer continuous to a depth of about 11 or 12 inches. Beneath this is lighter-brown loamy soil. The subsoil, between depths of about 15 and 36 inches, is the same color as the lower part of the surface horizon but is slightly heavier in texture and shows a slight lime accumulation. The next lower material is light-brown light silt loam or fine sandy loam and is underlain by a gravelly substratum. The fine sandy loam, loam, clay loam, and silty clay loam members of this series have been mapped.

The Minnequa soils differ from those described in that the profile is not well or completely developed, the lower layers not being readily distinguished from each other, and in that the deep subsoil contains partly disintegrated parent material. Where normally developed, the Minnequa soils are brown or grayish brown. A thin surface layer is highly granular and crusted. This is underlain to a depth of about 8 inches by less granular brown fairly friable soil beneath which is lighter-brown soil. This grades, at a depth ranging from 12 to 15 inches, into more distinctly yellowish-brown heavier material which in most places shows some accumulation of lime in spots

and alkali in many places. The deep subsoil is yellowish-brown sticky sandy clay or partly disintegrated shale. Where the parent material is very sandy it breaks down into a very light sandy clay or sandy loam. The silt loam, clay loam with a slope phase and a shallow phase, and clay members of this series have been mapped.

The Ordway soils are dark brown or olive brown in color, heavy in texture, and contain varying amounts of alkali. There is not a high accumulation of lime in the subsoil, and the deep subsoil consists of yellowish-brown or olive-brown partly disintegrated very gypsiferous shale. Ordway clay loam with a shallow phase, and Ordway clay with an adobe phase, have been mapped.

The Billings soils have developed from dark-gray or olive-brown clay shale. They are dark grayish brown or olive brown in color, heavy in texture, and contain alkali. On the surface is a thin finely granular layer crusted on top, in which alkali shows in many places. The soil shrinks and cracks, and alkali comes to the surface along the cleavage planes. Spots of lime accumulation are rare. The surface soil grades downward into the partly disintegrated shale, and this in the shallow phase grades into hard shale. These soils are largely shale outwash rather than true soils. Billings clay with a shallow phase has been mapped.

The Penrose soils have developed from thin, bedded, gray shaly limestone. They are light grayish brown. Small irregular fragments of shaly limestone are scattered over the surface and through the soil. The subsoil layer is slightly heavier in texture, shows a few indistinct spots of lime accumulation, and contains more shale fragments than the surface soil. Penrose loam with a heavy phase and a shallow phase has been mapped.

Soils of the Las Animas series are characterized by their brown, dark-brown, or dark grayish-brown color, somewhat grayish-brown or gray deep subsoil, and substratum of fine sand and silt mottled with rust brown and underlain by a deeper substratum of sand and stream gravel. Most soils of this series, especially the heavier ones, carry alkali in small or medium amounts. The sand, fine sandy loam with a heavy-subsoil phase, loam, clay loam with a valley phase, silty clay loam, and clay members of this series are mapped.

Soils of the Laurel series are characterized by brown, dark-brown, or slightly reddish-brown color; by a loamy texture, due in part to the presence of large quantities of finely divided mica; by a gravelly substratum; and by comparative freedom from alkali. Laurel fine sandy loam was mapped.

The Manvel soils have brown or dark grayish-brown finely granular surface soils underlain by lighter-brown material. The substratum closely resembles that of the Prowers soils. In places, especially on low terraces and alluvial fans, there is some indication of lime accumulation in the substratum, but this is less marked in the small valleys. In small valleys, soils of this series are from 6 to 10 or more feet deep, but on alluvial fans they thin out around the edge of the fan and are underlain by soils of the river valley, in many places by Las Animas soils. Manvel fine sandy loam and Manvel silt loam have been mapped.

The surface soils of the Apishapa soils are brown or slightly olive brown or grayish brown, are finely granular and loamy to a depth

of about 2 inches, are crusted at the surface, and in places show alkali. Below the surface soils is a layer about 12 inches thick of brown or light olive-brown heavy soil which shrinks and cracks, forming hard regular clods 1 or 2 inches through. The next lower layer is from 15 to 21 inches thick, is slightly lighter in color, heavy in texture, and contains some spots of lime accumulation. The lower layers, to a depth of 10 or more feet, consist of about the same material indistinctly stratified with very thin layers of lighter soil, fine sandy loam or silt loam, with small amounts of gravel. Apishapa silty clay loam has been mapped.

In addition to the soils mentioned, river wash, a miscellaneous class of material so varied that it could not be classed as a soil type, has been mapped.

In the following pages, the soil types are described in detail and their agricultural possibilities are discussed. Their distribution is shown on the accompanying soil map, and their acreage and proportionate extent are given in Table 3.

TABLE 3.—*Acreage and proportionate extent of the soils mapped in the Arkansas Valley area, Colo.*

Type of soil	Acres	Per cent	Type of soil	Acres	Per cent
Prowers loam	30, 848	4. 3	Minnequa clay	10, 176	1. 4
Prowers clay loam	49, 152	10. 8	Ordway clay loam	13, 056	2. 5
Poorly drained phase	28, 032		Shallow phase	5, 184	
Prowers fine sand	16, 000	2. 3	Ordway clay	17, 024	3. 3
Prowers loamy fine sand	10, 432	1. 5	Adobe phase	6, 144	
Heavy phase	320		Billings clay	25, 856	3. 8
Fort Lyon clay loam	9, 600	2. 2	Shallow phase	1, 152	
Shallow phase	6, 336		Penrose loam	4, 544	1. 9
Fort Lyon loam	11, 008	4. 4	Shallow phase	7, 552	
Level phase	12, 800		Heavy phase	1, 088	
Shallow phase	7, 744		Las Animas clay	17, 536	2. 5
Fort Lyon sandy loam	7, 232	1. 0	Las Animas silty clay loam	35, 392	5. 0
Fort Lyon gravelly loam	19, 200	2. 7	Las Animas clay loam	18, 304	3. 4
Otero sandy loam	47, 424	6. 8	Valley phase	5, 440	
Slope phase	1, 024		Las Animas loam	5, 312	. 7
Otero clay loam	30, 464	4. 9	Las Animas fine sandy loam	19, 904	3. 1
Poorly drained phase	3, 968		Heavy-subsoil phase	1, 920	
Otero loamy sand	7, 936	1. 1	Las Animas sand	4, 096	. 6
Rocky Ford loam	37, 568	5. 3	Laurel fine sandy loam	3, 648	. 5
Rocky Ford fine sandy loam	29, 312	4. 1	Manvel silt loam	9, 728	1. 4
Rocky Ford clay loam	10, 816	1. 5	Manvel fine sandy loam	2, 240	. 3
Rocky Ford silty clay loam	5, 248	. 7	Apishapa silty clay loam	15, 232	2. 1
Minnequa silt loam	24, 704	3. 5	River wash	11, 776	1. 7
Minnequa clay loam	30, 912	8. 7			
Slope phase	25, 536		Total	711, 680	
Shallow phase	5, 760				

PROWERS LOAM

Prowers loam is brown or light-brown smooth finely granular loam to a depth of 2 inches. This is underlain to a depth of about 15 inches by light-brown very smooth velvety loam. The subsoil is from 15 to 20 inches thick, is slightly lighter brown and heavier textured than the soil above it, and contains throughout, but most abundantly in the middle or lower part, small white flakes and irregular spots of lime accumulation. The substratum is of the same light-brown color as the material above it, but is distinctly lighter in texture, at a depth of 5 feet being coarse silt and in places almost very fine sandy loam. (Pl. 1, B.) The substratum continues to a depth of 4 or more feet, over much of the area extending to a depth

considerably greater than 5 feet. Underneath it at widely varying depths is reddish-brown sandy clay which forms the subsoil of the adjacent lower-lying Fort Lyon soils.

In cultivated fields the soil is slightly lighter and more grayish brown than the virgin soil. It crusts slightly after rains or irrigation, but the crust is fairly easily broken as are also the clods which form under cultivation. In roadside cuts, ditches, and gully banks this soil weathers with a somewhat columnar structure and horizontal cleavage.

This is the most uniform soil of the region in color, texture, and thickness. Areas recently brought under cultivation are lighter and more grayish in color than areas which have been used for some time for alfalfa and pasture land. In a very few places where this soil lies on a slope below a main-line canal alkali has come to the surface on account of seepage and the imperviousness of the substratum. As a whole, however, this is the most nearly alkali-free soil in the area. All layers effervesce freely with hydrochloric acid.

Prowers loam occupies the tops and better-drained parts of the low broad ridges which lie at right angles to the main valley from the Kansas State line to near McClave.

Moisture requirements, on account of the fine silty texture and open subsoil, are low. The material takes up water readily. It allows the escape of the surplus through the subsoil and tends to release moisture as needed.

This soil has a wide crop adaptation. It is used principally for alfalfa (pl. 2, A), sugar beets, small grains, and corn. In fertility and texture it seems well suited to nearly all the special crops now being grown in the Arkansas Valley on other soils. Under irrigation this soil, like all soils of this region, becomes slightly heavier in texture.

Table 4 gives the results of mechanical analyses of samples of the surface soil and subsoil of Prowers loam.

TABLE 4.—*Mechanical analysis of Prowers loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
490748	Surface soil, 0 to 2 inches	1.0	1.9	1.0	4.6	44.7	39.5	7.5
490749	Subsoil, 2 to 15 inches	.2	.7	.4	3.8	38.2	43.1	13.9
490750	Subsoil, 15 to 30 inches	.0	.2	.2	2.1	37.0	48.2	12.6
490751	Subsoil, 30 to 60 inches	.0	.1	.2	2.2	43.9	43.3	9.9

PROWERS CLAY LOAM

The surface soil of Prowers clay loam consists of brown or light-brown finely granular clay loam containing considerable organic matter and grass roots. There is a slight or medium crust on the surface. This layer is underlain to a depth of about 15 inches by light-brown coarsely granular clay loam breaking into small irregular clods from one-eighth to one-fourth inch through. The subsoil, which is from 15 to 20 inches thick, consists of clay loam rather dis-

tinctly heavier than the material above it and containing white flakes and spots of lime accumulation, especially at a depth of about 30 inches. The substratum is light-brown silt loam nearly or entirely free from lime spots. This differs from the deep layer of Prowers loam in being slightly lighter in color and heavier in texture. This layer extends to a depth of 5 or more feet in most places.

The principal variation in this soil is in texture of the surface soil, which ranges from silt loam to heavy loam. In general the surface soil is darkest and heaviest on the flattest, most poorly drained areas.

Prowers clay loam is closely associated with Prowers loam but is slightly darker and heavier than that soil and occupies more nearly level areas. Neither surface drainage nor underdrainage is quite so good as in soils of lighter texture, but they are fair or good. Alkali as a rule is not present in sufficient quantities to be very harmful. Moisture requirements are good but are slightly higher than for Prowers loam. The clay loam is also more difficult to handle; it crusts, bakes, and cracks more readily and the clods are harder; and good stands of crops are obtained with a little greater difficulty.

The crops grown on this soil are the same as on Prowers loam, and yields as a whole are possibly a little higher. The clay loam does not seem quite so well suited to special, intensively cultivated crops.

This is the most extensive soil in the area. It extends from the Kansas State line to a north-and-south line a short distance west of Hasty and is the most important soil in the highly developed May Valley and Big Bend sections.

Prowers clay loam, poorly drained phase.—The surface layer of Prowers clay loam, poorly drained phase, is dark-brown or dark grayish-brown finely granular silty clay loam containing much organic matter and firmly crusted at the surface. The subsurface soil, to a depth of about 15 inches, is dark grayish-brown heavy sticky silty clay loam. On drying it shrinks and cracks badly, and in cultivated fields large hard irregular clods form. White accumulations of alkali are to be found in many places in the surface and subsurface layers. The subsoil, extending to a depth between 30 and 36 inches, is lighter in color and slightly heavier in texture than the material above it and contains more white spots of lime accumulation. The substratum is light-brown or grayish-brown clay loam, differing little from that of the typical soil.

This phase of Prowers clay loam occupies numerous small shallow valleys, lying from 4 to 10 or more feet below adjacent areas of the typical soil, and broader flat or slightly basinlike upland depressions. As a whole, it seems to contain slightly more organic matter and to be less well drained than the typical soil. On account of the position of the areas alkali has accumulated in many places. When adequate outlets for underdrainage have been provided the land is quickly reclaimed. It is highly productive and is suited to the same crops and gives the same yields as Prowers clay loam.

Table 5 gives the results of mechanical analyses of samples of the surface soil and subsoil of typical Prowers clay loam and of Prowers clay loam, poorly drained phase.

TABLE 5.—*Mechanical analyses of Prowers clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907239	Surface soil, 0 to 2 inches	0.4	2.1	1.6	10.5	41.0	30.3	14.2
4907240	Subsoil, 2 to 14 inches	9.7	15.6	5.8	12.2	6.9	18.7	31.3
4907241	Subsoil, 14 to 36 inches	.8	4.0	2.4	4.6	10.2	45.5	32.4
4907242	Subsoil, 36 to 72 inches	1.6	8.2	4.4	8.2	19.2	31.0	27.6
	POORLY DRAINED PHASE							
4907235	Surface soil, 0 to 2 inches	0.2	2.8	2.0	10.6	36.4	31.4	16.3
4907236	Subsoil, 2 to 15 inches	.4	3.6	3.1	9.6	37.6	25.8	19.9
4907237	Subsoil, 15 to 30 inches	.2	1.5	1.8	6.8	39.8	27.9	22.4
4907238	Subsoil, 30 to 65 inches	.2	1.8	1.2	3.7	35.0	35.7	22.5

PROWERS FINE SAND

Prowers fine sand has a 3-inch surface layer of brown or slightly reddish-brown loose incoherent sand or fine sand, underlain by very slightly lighter-brown loose incoherent fine sand continuous to a depth of several feet.

This soil occupies rather extensive upland areas on both sides of Arkansas River. The most extensive area north of the river lies east of Big Sandy Creek midway between Granada and Lamar. South of the river the soil extends from the Kansas State line west nearly to Caddoa.

Areas of this soil are undulating or rolling, and in places, especially where the land has been broken, the material has been blown into dunes with intervening "sand blows" which make the relief very uneven and choppy. The loose sand fills roads and ditches. Virgin areas afford some pasturage of buffalo and grama grasses with, in places, some bluestem.

PROWERS LOAMY FINE SAND

To a depth of about 3 inches Prowers loamy fine sand is brown or fairly dark-brown slightly granular loamy fine sand containing considerable organic matter and only slightly crusted at the surface. This is underlain by lighter-brown somewhat granular and loamy material about 12 inches thick. The subsoil, which is from 12 to 15 inches thick, has nearly the same color and texture but contains a few indistinct white spots of lime accumulation. Below a depth of 25 or 30 inches the sand is much like that in the surface layer but is not loamy. Although the percentage of coarse material in the surface soil and subsoil is small, sufficient medium and coarse sand is present to give a coarse texture.

This soil is of very recent origin and has resulted largely from the use of irrigation water carrying large quantities of silt. Its loamy texture is believed to be caused by the heavy silt left from the water.

Prowers loamy fine sand, heavy phase.—Prowers loamy fine sand, heavy phase, consists of very heavy loamy fine sand, fine sandy

loam, loam, or even heavier soil from 6 to 15 inches thick, underlain by the typical loamy fine sand subsoil. The soil is derived from the accumulation of silt from irrigation water in low places.

Numerous small areas of this heavy phase, in association with the typical soil, extend along the south side of the valley from the eastern limits of the area to near Prowers. Areas are nearly level or occupy long gradual slopes where the sand has been blown into the valley in comparatively recent times. It is said that irrigation with the silty river water for a period of only a few years will change sand to comparatively heavy loamy sand.

Prowers loamy fine sand, heavy phase, is used principally in the production of corn and alfalfa.

FORT LYON CLAY LOAM

Fort Lyon clay loam has a brown or slightly reddish-brown finely granular rather coarse loam surface layer about 2 inches thick, over which is a fairly hard crust. This layer is underlain to a depth of about 12 inches by brown or slightly reddish-brown heavy clay loam or silty clay loam containing some coarse sand and fine sharp gravel. This material forms hard irregular clods and contains a few lime spots in the lower part. It is underlain by rather distinctly reddish-brown heavy clay loam or silty clay containing more lime spots, especially in the lower part. Its thickness differs from place to place but averages about 24 inches. The next lower material is sharply defined light-gray or nearly white silty clay very rich in lime. (Pl. 2, B.) This layer has a thickness ranging from 18 to 24 inches and is underlain by soil of lighter texture.

Fort Lyon clay loam extends as a broad belt along the north side of the valley from near Kreybill almost to La Junta. It has a nearly uniform slope toward the river, and for this reason underdrainage is fairly good. The lower part of this belt merges into Rocky Ford silty clay loam, but there is little surface indication of the line separating the Fort Lyon soil, with its layer of high lime concentration, from the Rocky Ford soil, in which lime occurs only in spots. East of Adobe Creek is a rather large, heavy-textured area, which has doubtless been modified by deposits from the creek. Surface drainage is good, and there are few if any large surface accumulations of alkali, although in some spots and belts the soil does not take water readily and crops do not grow well.

This is considered one of the most productive soils in the valley for sugar beets. It is used extensively for all crops grown in the lower part of the valley.

Fort Lyon clay loam, shallow phase.—The shallow phase of Fort Lyon clay loam differs from the typical soil in that both the reddish-brown sandy clay layer and the light-gray layer of lime accumulation are thinner, and in that shale material underlies it at a depth ranging from 3 to 6 feet. It closely resembles soils of the Minnequa series in the depth to shale.

On some spots of shallow Fort Lyon clay loam, seepage has developed. Such areas as a whole are less productive than the typical soil. The soil of this phase occurs in association with the typical soil and is utilized in the same way.

Table 6 gives the results of mechanical analyses of samples of the surface soil and subsoil of typical Fort Lyon clay loam.

TABLE 6.—*Mechanical analyses of Fort Lyon clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907213	Surface soil, 0 to 2 inches	2.2	10.1	5.6	14.2	24.2	27.1	16.4
4907214	Subsurface soil, 2 to 12 inches	2.6	8.9	4.6	11.8	18.8	32.0	21.4
4907215	Subsoil, 12 to 24 inches	6.6	16.4	6.0	8.8	16.6	26.1	19.2
4907216	Subsoil, 24 to 45 inches	4.8	16.8	7.3	12.8	11.8	24.3	22.4
4907217	Subsoil, 45 to 72 inches	2.7	16.1	9.9	21.4	14.4	18.2	17.8

FORT LYON LOAM

To a depth ranging from 1 to 3 inches, Fort Lyon loam consists of brown finely granular sandy loam or loam, somewhat crusted at the surface and containing a small amount of coarse sand, sharp gravel, or small rounded gravel. The second layer, which is 10 or 12 inches thick, consists of slightly lighter-brown clay loam, also somewhat granular and friable, which on weathering forms large irregular rather easily broken clods. The next lower material is reddish-brown or chestnut-brown heavy clay loam which breaks into hard clods with rather regular horizontal and transverse fractures and contains well-defined lime spots which are more numerous in the lower part of the layer. Below an average depth between 24 and 30 inches is a light-gray or almost white layer consisting very largely of carbonate of lime. This layer is from 18 to 24 inches thick and is underlain by light-brown fine sandy loam in which are thin stratified layers of sand and fine gravel, by shale, or by thin-bedded shaly limestone.

This soil ranges rather widely in texture, in thickness of the surface soil, the reddish-brown layer, and the lime layer, and in character of the deep substratum.

Areas of Fort Lyon loam are sloping. They occur as long narrow strips between the uplands covered by Prowers loam and Prowers clay loam and the shallow valleys occupied by Prowers clay loam, poorly drained phase. The soil is also found on the slopes of gravel-capped mounds and ridges.

Surface drainage of the greater part of this soil is good, but underdrainage, on account of the heaviness and imperviousness of the deep subsoil, is restricted. Irrigation and rain waters sink to the top of the heavy layer, along which moisture tends to move laterally, and come to the surface farther down the slope as seeped spots. On evaporation, areas of alkali accumulation are formed. Many of the alkali areas outside of the valleys and small basins are formed in this way.

Although moisture requirements of this soil are higher than of the Prowers soils, because of the heavy subsoil, water should be used sparingly on account of danger from seepage.

The natural vegetation includes buffalo and grama grasses, together with some needle grass, yucca, weeds, wild alfalfa, and

morning-glory. The soil is used for the same crops as the adjacent soils, with perhaps a somewhat larger acreage in alfalfa. Yields are slightly lower.

Fort Lyon loam, level phase.—The 2 or 3 inch surface layer of Fort Lyon loam, level phase, consists of brown finely granular loam containing considerable coarse sand and some caliche fragments and is slightly crusted at the surface. The second layer is about 12 inches thick and consists of brown or light-brown clay loam which, where exposed, shows a slight tendency to columnar structure. A few shale or caliche fragments are distributed through it. The next lower layer, which is about 15 inches thick, is slightly heavier in texture and contains shale fragments and a few spots of lime accumulation in the lower part. This layer is underlain to a depth of about 48 inches by brown or slightly reddish-brown heavy clay loam in which well-defined lime spots are abundant. The next lower material is nearly white silty clay loam or clay.

A number of variations were included in mapping. Near the small streams which cross the valley are long narrow areas in which the shale and caliche fragments are very numerous and somewhat stratified. Such areas are somewhat droughty and are not very productive. In other places where this soil is adjacent to areas of the Minnequa soils the surface soil is heavy and the deep subsoil is heavy gypsiferous shale. In other places there is on the surface a thin layer of reddish-brown sandy or loamy soil which gives areas the appearance of the Otero soils.

Areas are nearly level, but some long narrow strips occupy gradual slopes. Surface drainage is good, and on account of the depth to the layer of heavy lime accumulation underdrainage seems better than in the typical soil.

This phase of soil is well developed around Lubers. Here it is a productive soil approaching Prowers clay loam in crop value. It is extensive from Keesee to Kreybill.

Fort Lyon loam, shallow phase.—Fort Lyon loam, shallow phase, occurs in the eastern part of the valley, mainly as low mounds or ridges in which only a shallow soil covering lies over hard light-gray shaly limestone, caliche, or hard lime hardpan. Most of these areas lie above the level of irrigation ditches. In many places they are occupied by prairie dogs, which bring much of the rock material to the surface. Such land is used only for grassland. The common growth includes buffalo grass, grama grass, cactus, and yucca.

Other areas mapped as the shallow phase of Fort Lyon loam occur along the steeper slopes bordering the river valley and, in places, the tributary streams. The material is fine sandy loam or loam, in many places covered with stream gravel, underlain by shale or shaly limestone. The white accumulation of lime characteristic of the Fort Lyon soils is in most places present. These areas also are used only for grassland.

Table 7 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of typical Fort Lyon loam and of Fort Lyon loam, level phase.

TABLE 7.—*Mechanical analyses of Fort Lyon loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907243	Surface soil, 0 to 2 inches	1.2	11.3	7.2	14.6	21.2	26.5	17.1
4907244	Subsurface soil, 2 to 12 inches	.8	5.6	3.4	8.3	37.4	35.0	9.8
4907245	Subsoil, 12 to 30 inches	.0	.2	.2	1.6	32.8	47.3	17.5
4907246	Subsoil, 30 to 45 inches	.0	.4	.4	2.0	25.6	50.4	21.1
4907247	Subsoil, 45 to 60 inches	.2	1.8	1.8	6.8	39.8	32.1	17.7
	LEVEL PHASE							
4907256	Surface soil, 0 to 2 inches	0.8	5.4	4.6	17.1	30.8	27.6	14.0
4907257	Subsurface soil, 2 to 10 inches	.6	2.8	2.2	9.2	31.8	35.2	18.2
4907258	Subsoil, 10 to 36 inches	.6	1.8	1.0	3.4	26.0	46.3	20.9
4907259	Subsoil, 36 to 54 inches	1.4	5.2	3.8	13.4	20.8	26.2	29.1

FORT LYON SANDY LOAM

Fort Lyon sandy loam has a 2 or 3 inch surface layer of brown or light-brown finely granular fine sand or fine sandy loam slightly crusted at the surface, underlain by a layer, from 12 to 15 inches thick, of brown or reddish-brown medium sandy loam or loam showing slight tendency to columnar structure. Below this is a layer, from 16 to 20 inches thick, of light reddish-brown rather coarse heavy loam containing some poorly defined white lime spots. This material forms clods which crumble easily. Below it is a slightly re[illegible]h-gray layer of loam containing rather large quantities of lime in poorly defined spots. Below a depth of 48 inches is light friable loam or sandy loam containing little lime.

This is not a very uniform soil. It includes areas of sand and sandy loam. In some places, as along both sides of Wild Horse Creek north of Holly, the surface soil is reddish brown and much medium or coarse sand is present. Near Big Bend, included areas appear much like the Otero soils but have a more highly developed lime layer.

This soil occurs along both sides of Wild Horse Creek north of Holly and along the slopes of the small valley in which Wiley is located. Some areas are nearly level, but most of the land occurs near small streams and is gradually sloping. Surface drainage is good, and the lime horizon does not seem sufficiently heavy to seriously check underdrainage. Alkali has not accumulated in injurious quantities. On account of its texture and open subsoil, moisture requirements are high. This soil is used principally for growing corn, alfalfa, and small grains. It is somewhat less productive than the heavier soils of this series.

FORT LYON GRAVELLY LOAM

Fort Lyon gravelly loam consists of a mass of rounded stream gravel of widely varying composition, ranging in diameter from one-half inch to 4 or more inches. This gravel is somewhat stratified. There is a well-defined layer of heavy lime accumulation, and white lime coats the gravel, especially on the lower side. A surface covering a few inches thick of sand, fine sand, and silt overlies the gravel beds in most places.

The gravel is of alluvial origin, evidently deposited long ago when Arkansas River occupied a much broader flood plain than at present. The deposits were doubtless originally much more extensive, and the cappings of the hills are only remnants of the older more extensive beds. North of Manzanola, along the highway between Fowler and Avondale, and in other places the gravel is somewhat cemented into a soft conglomerate.

Along the edge of the more recently deposited river terraces, exposed beds of gravel having a less well-defined layer of lime accumulation have been included in mapping. All the soil is nonagricultural, but these gravel beds have been an important factor in maintaining the terraces and checking erosion.

OTERO SANDY LOAM

Otero sandy loam has a surface layer of brown finely granular fine sand or fine sandy loam, very slightly crusted at the surface. Below this is a layer, 10 or 12 inches thick, of dark-brown, reddish-brown, or chestnut-brown loose friable fine sandy loam or light loam. On exposure to weathering this material shows a tendency to break with somewhat regular cleavage. The subsoil, which is from 16 to 21 inches thick, is light brown and heavier in texture and contains numerous well-defined lime spots. It forms fairly hard clods when exposed to weathering and breaks with less regular cleavage than the surface soil. The substratum, between depths of about 30 inches and 5 or more feet, consists of light-brown fairly friable loam or clay loam which becomes lighter in texture in the lower part.

The principal variation is in the texture of the surface soil. The greater part of this land before being irrigated was sandy loam or fine sandy loam, but under irrigation it has in most places become light loam. In places, too, sand has been blown into mounds and ridges covering the typical soil. Enough medium and coarse sand are present to give the material a rough feel.

Areas of this soil occupy nearly level upland and in most places lie slightly higher than adjacent areas of heavier soils. Surface drainage is generally good. In a few areas extending into basins the water table has been raised by underground seepage. On account of its openness, the moisture requirements of this soil are rather high.

The natural vegetation includes a large proportion of sage, especially where the surface soil is light. The soil is used in the production of alfalfa, beans, and melons.

This soil is extensive on the uplands from Horse Creek westward to Olney Springs, on the north side of Arkansas River, and on the south side from Timpas Creek to Huerfano River. The more important areas under irrigation are around Holbrook Lake and Cheraw, from Crowley to Olney Springs, south of Fowler, and between Fowler and Huerfano River.

Otero sandy loam, slope phase.—Otero sandy loam, slope phase, has a 2 or 3 inch surface layer of brown finely granular sandy loam or loam, which in places is slightly gravelly. It contains considerable organic matter and is slightly crusted at the surface. This is underlain to a depth of about 14 inches by brown or slightly reddish-brown loam which is heavier in the lower part. The sub-

soil, which is 15 or 20 inches thick, consists of distinctly heavier loam or heavy clay loam. The substratum is variable. In some places it is much like that under Prowers clay loam and in other places more nearly resembles the sandy clay subsoil of the Otero soils.

This soil is well drained, is comparatively free from alkali, and has about the same crop adaptations as the adjacent soils of this series. As a whole, however, it is somewhat less productive than associated soils.

The principal areas of the soil extend along the slopes near May Valley and south and west of Thurston Lake.

Table 8 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of typical Otero sandy loam.

TABLE 8.—*Mechanical analysis of Otero sandy loam*

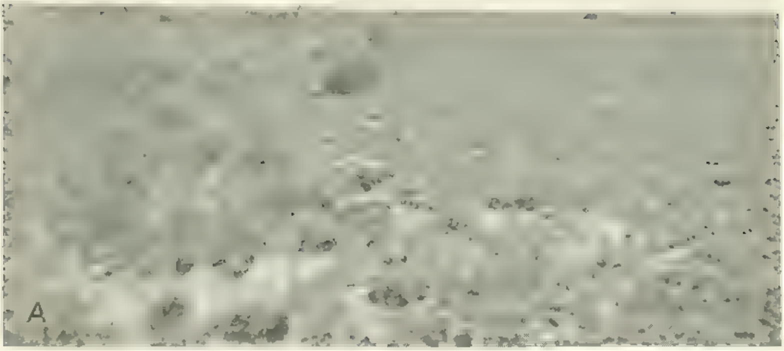
No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
490767	Surface soil, 0 to 2 inches	1.9	10.3	7.4	33.0	31.1	12.1	4.7
490768	Subsurface soil, 2 to 8 inches	1.5	7.5	7.1	36.4	23.6	15.3	8.3
490769	Subsoil, 8 to 12 inches	2.5	8.2	6.6	32.4	24.4	17.6	9.1
490770	Subsoil, 12 to 30 inches	1.2	8.7	7.0	28.5	19.2	20.9	14.8
490771	Subsoil, 30 to 42 inches	.2	1.8	2.0	9.6	28.2	36.8	21.9
490772	Subsoil, 42 to 60 inches	.8	4.8	7.4	40.4	22.4	11.2	13.4

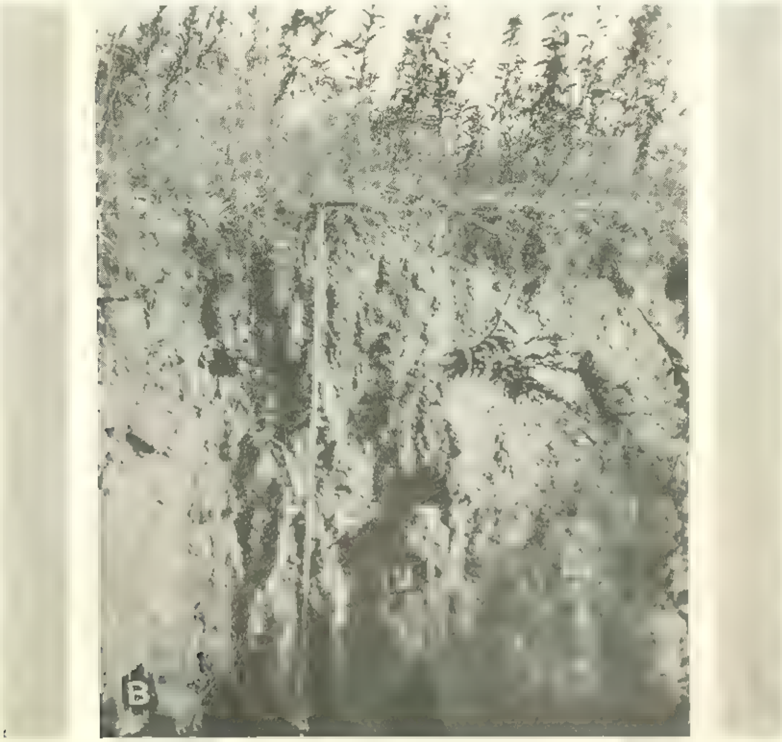
OTERO CLAY LOAM

The surface layer of Otero clay loam, to a depth of 2 or 3 inches, is brown finely granular loam with a rough feel. This is underlain to a depth of 10 or 12 inches by reddish-brown or chestnut-brown heavy loam which shows a distinct tendency to a columnar structure and which under cultivation forms rather hard clods. In the lower part this layer is slightly lighter brown and contains some whitish spots of lime. The subsoil between depths of 12 and 30 inches consists of light-brown heavy clay loam containing numerous well-defined lime spots. Hard irregular clods form where the material is exposed to weathering. Below a depth ranging from 30 to 36 inches is a brown or light-brown light clay loam or light sandy clay substratum. At widely varying depths this rests on shaly limestone or shale.

The principal variations in this soil result from differences in texture and changes that have taken place due to restricted underdrainage or to accumulation and rise of ground water.

Otero clay loam occupies nearly level areas or the lower part of slightly basinlike areas. It is closely associated with Otero sandy loam but occurs in slightly lower positions. Surface drainage for the most part is good. Underdrainage was originally good also, but it has in places become bad through the filling of the lower part of the basin in which the soils occur with seepage water from higher areas. Rise of the water table not only makes subsoil conditions unfavorable for plant growth but also results in the accumulation of alkali at the surface. For this reason artificial drainage for much of this soil has become necessary.





A, Uplands northwest of Caddoa, showing native vegetation of buffalo and grama grasses. B, gully bank showing columnar structure of Prowers loam near a depth of 5 feet

A, Field of alfalfa on Prowers loam near Bristol; B, profile of Fort Lyon clay loam, showing highly developed white layer

Alkali has accumulated in injurious amounts in all the poorly drained areas. Moisture requirements, on account of the comparatively heavy subsoil and loamy surface soil, are low or medium.

This soil is well suited to all general farm crops of the region, including alfalfa, sugar beets, corn, beans, and melons. Crop yields are good.

Otero clay loam, poorly drained phase.—Otero clay loam, poorly drained phase, has a 2-inch surface layer of dark-brown finely granular loam crusted somewhat at the surface or containing white loose masses of alkali. This is underlain to a depth of 8 inches by dark-brown sticky clay loam containing large quantities of alkali along old root channels and on exposure showing distinct adobelike or columnar structure. The next lower layer, which continues to a depth of about 24 inches, is lighter-brown heavy clay loam containing less alkali than the upper layers. It forms clods on drying, but these are fairly easily broken. The substratum between depths of 24 inches and 6 or more feet is light-brown or yellowish-brown fairly sandy clay.

This phase of Otero clay loam occupies the lowest, most poorly drained parts of the shallow depressions in which the Otero soils occur. The present condition of the soil has been brought about very largely by lack of drainage and the resultant accumulation of alkali. The principal vegetation is salt grass and various kinds of alkali weeds. The soil in its present condition has no value for cultivated crops, but on account of favorable subsoil conditions it can readily be reclaimed by drainage. The largest tract of this soil in this area lies south of the Missouri Pacific Railroad between Olney Springs and Crowley. A strip occupies the lower part of Patterson Hollow southwest of Rocky Ford, and smaller areas lie between Holbrook and Cheraw Lakes.

There is but little doubt that this soil can be reclaimed and made productive at comparatively low cost and within a reasonably short time. Thorough drainage, cultivation, washing down of the surface alkali, and seeding as quickly as possible to the most resistant crops are important steps in reclamation.

OTERO LOAMY SAND

Otero loamy sand has a slightly crusted 2-inch brown finely granular medium or fine loamy sand surface layer. Below this is a layer about 10 inches thick of brown, dark-brown, or slightly reddish-brown medium loamy sand or light sandy loam showing columnar structure. The clods are easily broken. The material is slightly lighter brown in the lower part. The subsoil between depths of 12 and 30 inches is light-brown light loam or fine sandy loam with well-defined columnar structure. In the upper part of this layer the lime is well distributed, giving the entire soil a light-brown or grayish-brown appearance, but below a depth of 18 inches it occurs in well-defined white spots and the soil is more easily broken and crumbled. Below a depth of 30 inches is slightly yellowish-brown light fine sandy loam, very loose when dry but sticky when wet.

93959—30——3

Where cultivated this soil drifts and blows. As its water requirement is high and the greater part of it is above ditch level, it has a very low agricultural value and but little of it is under cultivation. The natural vegetation is largely sage.

ROCKY FORD LOAM

Rocky Ford loam has a 1-inch surface layer of brown finely granular loamy sand or fine sandy loam, very slightly crusted. This is underlain to a depth of 10 or 12 inches by brown or dark reddish-brown mellow friable fine-textured fine sandy loam or light loam. Where exposed in roadside cuts the material breaks into somewhat regular clods 1 inch through. Distributed through this layer is a small amount of medium and coarse sand. The next lower layer consists of light-brown fine-textured loam extending to a depth of about 36 inches. This layer is heavier in texture than the soil above it or the deep subsoil below it. Light-gray spots of lime accumulation are present. The deep subsoil of light silt loam is underlain by fine sand and stream gravel at a depth ranging from 6 to 10 or more feet.

The principal variations in this soil are in texture. In general the areas of lighter texture are along the river side of the terrace and on the slightly higher-lying areas and slight ridges, and those of heavier texture occupy the parts toward the uplands and the slightly lower-lying or less well-drained areas.

The highly developed agricultural region near Avondale is on a comparatively uniform area of this soil. West of Manzanola the subsoil in included areas is not typical on account of heavier soil material which has been carried into the valley by a small tributary stream. From Horse Creek westward to a point a mile northwest of Casa a considerable part of the low terrace is occupied by a rather heavy phase of this soil, which also lacks uniformity in texture in the surface soil. On the high Lincoln Park terrace near Canon City the substratum consists of a deep layer of very fine sand which is, in turn, underlain by stream gravel.

This is the most extensive and important soil on the terraces extending along the south side of Arkansas River most of the way from La Junta to Canon City. Surface drainage and underdrainage are both good. Alkali in harmful amounts is present in only a very few places. Moisture requirements are low.

This soil is well suited to nearly all crops of this region, especially to crops requiring intensive cultivation and nice moisture adjustment. It is used extensively for cantaloupes (pl. 3, A) and cucumbers for seed, for other seed crops, for red clover, Lima beans, and zinnias (pl. 3, B), and at Lincoln Park for tree and small fruits. Wheat also does well. (Pl. 3, C.)

Table 9 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of Rocky Ford loam.

TABLE 9.—*Mechanical analysis of Rocky Ford loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cen*
490777	Surface soil, 0 to 2 inches	0.4	2.4	2.4	14.8	37.7	30.5	12.3
490778	Subsurface soil, 2 to 9 inches	0	2.1	2.6	21.0	40.6	22.9	10.9
490779	Subsoil, 9 to 20 inches	0	1.0	1.4	8.0	35.1	44.2	10.9
490780	Subsoil, 20 to 36 inches	0	1.4	2.0	11.9	41.3	28.4	15.5
490781	Subsoil, 36 to 66 inches	0	.6	1.0	8.4	42.6	34.4	13.3

ROCKY FORD FINE SANDY LOAM

Rocky Ford fine sandy loam has a surface layer, about 1 inch thick, of very slightly sticky brown or dark-brown finely granular loamy sand or fine sandy loam which is slightly crusted. Below this is brown or very slightly reddish-brown light fine sandy loam containing some medium and coarse sand, the larger grains of which are sharp and irregular. The soil has a vertical cleavage, flaking off in layers from one-fourth to one-half inch thick, which crumble easily. Below a depth of about 12 inches is the subsoil of lighter-brown fine sandy loam, lighter colored in places and containing a few well-defined lime spots. This is underlain, at a depth ranging from 24 to 36 inches, by light sandy loam, sand, and stream gravel which has a white coating of lime.

This soil shows rather wide variations in texture and thickness. In general the more sandy and shallow areas containing larger quantities of gravel occur along the stream edge of the terrace as narrow strips along the steeper slope. In places these areas are too shallow and gravelly for high crop production. Low ridges are in general more sandy and gravelly than the level areas, and the slightly lower less well-drained areas are heavier.

In the vicinity of Fowler much of the soil toward the south side of the area contains shale material in the deep subsoil, and in other places a thick layer of lime accumulation like that underlying the Fort Lyon soils is to be seen. Here the terrace soils are so shallow that the underlying subsoil material of other soils is reached at a depth of less than 5 feet.

Immediately east of Huerfano River is a rather large area in which the soil is somewhat more reddish brown and gravelly than typical Rocky Ford fine sandy loam. On the St. Charles mesa extending from St. Charles River to Pueblo are areas in which the material is very light in texture and rather uneven, slightly heavier soil occupying numerous narrow low belts. In many small areas the lime-coated gravel comes near the surface. At Lincoln Park areas of very fine sandy loam have been included, and east of Purgatoire River a rather large included area has a well-developed layer of lime accumulation.

Drainage of the greater part of this soil is good or excessive, on account of the sandy texture of the soil and the openness of the gravelly subsoil. A few low-lying areas, however, are kept wet by accumulated seepage. Alkali is present in injurious quantities only in the lower-lying areas. It is much more harmful in this soil than the

same amount would be in a soil of heavier texture. Moisture requirements are high.

This soil is well suited to specialized crops requiring intensive cultivation. The St. Charles mesa is used almost exclusively for market-garden crops. Farther down the valley melons, tomatoes, seed crops, alfalfa, sugar beets, and nearly all other crops common to the region are grown. Crop yields average lower than on Rocky Ford loam.

This soil occupies a fair proportion of the terraces from Timpas Creek to St. Charles River and is the predominant soil from that river to Pueblo.

ROCKY FORD CLAY LOAM

Rocky Ford clay loam has a 1-inch surface layer of dark-brown finely granular loam or clay loam underlain by a 10-inch layer of less-granular dark-brown clay loam showing a slight columnar structure. This layer breaks into clods and shows white material along cleavage planes and root channels. The next lower layer is lighter-brown clay loam with well-defined white spots of lime below a depth of 20 inches. Below a depth ranging from 30 to 36 inches this layer grades typically into a lighter-textured layer which is underlain by stream gravel.

Over considerable areas this soil differs from Rocky Ford loam in having a slightly heavier surface soil which has resulted largely from deposits of silt by irrigation water. Near the stream edge of the terrace the alluvial material is thin and lies over shale material which restricts underdrainage. This causes the surface soil to become heavier under irrigation. There have also been included in mapping a number of slightly lower-lying strips along small drainage ways which cross the terraces. In these areas the soil is poorly drained and sticky, and the subsoil is rather heavy. Alkali is present in most places in varying quantities. Near Fort Lyon a considerable area in which the soil is fairly light and contains stream gravel has been included, and along Adobe Creek another included area is not typical of the soil on the terraces.

A large area of Rocky Ford clay loam lies east of Timpas Creek south of Swink, and other areas occupy a rather large part of the terrace from Swink to Manzanola. The soil is used to a considerable extent for growing cantaloupes, cucumbers, and other crops requiring good management but is probably better suited to alfalfa, corn, and small grains.

Table 10 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of typical Rocky Ford clay loam.

TABLE 10.—*Mechanical analysis of Rocky Ford clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907130	Surface soil, 0 to 2 inches	0.0	0.8	1.0	6.9	29.4	37.1	25.2
4907131	Subsurface soil, 2 to 10 inches	.0	.8	1.0	6.2	28.4	38.4	25.1
4907132	Subsoil, 10 to 28 inches	.2	.0	.0	5.2	34.8	40.0	19.6
4907133	Subsoil, 28 to 45 inches	.0	.3	.4	2.9	42.5	32.7	20.5
4907134	Subsoil, 45 to 75 inches	.2	1.5	1.6	7.0	31.8	33.8	24.4

ROCKY FORD SILTY CLAY LOAM

To a depth of about 12 or 14 inches, Rocky Ford silty clay loam consists of brown, dark-brown, or slightly reddish-brown soil, finely granular at the surface and containing a few small spots of lime in the lower part. The next layer, continuing to a depth of about 30 inches, is lighter-brown heavier silty clay loam containing numerous well-defined lime spots. Below a depth ranging from 30 to 36 inches is a light-brown distinctly lighter-textured silt loam or very fine sandy loam.

This soil has two important variations. Along the riverside the deep subsoil is light in texture but toward the higher valley part it becomes distinctly heavier, grading into the adjacent Fort Lyon soils without any surface indication. The second variation is in the surface soil, which is fairly light in texture and in places contains some gravel, but which in the vicinity of Cornelia and westward to Adobe Creek is very heavy, doubtless owing to the presence of heavy material which during the time of terrace development was deposited by that creek. In a third variation, consisting of a narrow strip which occupies the terrace edge the surface soil has been partly removed by erosion, leaving the heavier much less productive subsoil exposed at the surface. The principal area of this kind extends from near Fort Lyon westward to beyond Horse Creek.

Rocky Ford silty clay loam is used extensively for growing alfalfa, sugar beets, corn, and small grains. Crop yields, except along the eroded terrace edge, are good. This soil, together with the adjacent Fort Lyon soils, is considered by farmers among the most productive in the valley for general farm crops.

MINNEQUA SILT LOAM

Minnequa silt loam has a 1 or 2 inch surface layer of dark-brown finely granular loam. Between depths of 2 and 12 inches is dark-brown heavy silt loam, distinctly columnar in structure, which breaks into easily crumbled clods 1 or 2 inches through. Below a depth of 12 inches is slightly lighter-brown silt loam of less marked columnar structure and containing some small white spots of lime, much less numerous, however, than in the adjacent areas of clay loam. Below a depth of 24 inches is light-brown or grayish-brown light silt loam containing a few small lime spots in the upper part. Below an average depth of about 36 inches is yellowish-brown soft rotten sandy shale 2 or 3 feet thick, which rests on harder darker-colored shale. Whether this soil has developed from weathered shale alone or has been influenced by a thin deposit of wind-blown material is not known, but the surface soil has much the appearance and texture of wind-blown material.

This soil occurs principally in Pueblo County south of Avondale and Vineland, where it occupies low broad ridges of upland. It is comparatively uniform, the principal variation being in the shallowness of the soil on the slight slopes surrounding the main areas. Areas are nearly level but are well drained. Alkali has accumulated in only a few shallow tracts near slopes. There seems little danger of the accumulation of large quantities of alkali.

On account of its texture and thickness, moisture requirements are not high. Native vegetation consists largely of buffalo and grama grasses. On the adjacent slightly lower-lying soils shad scale is abundant.

This soil is well suited to nearly all crops of this region. At present it is used for alfalfa, corn, and sugar beets. It more nearly approaches the Prowers, Rocky Ford, and Otero soils in crop value than do any other soils with incompletely developed profiles. This is owing to its fine silty texture, its thickness, and its position on the ridges.

MINNEQUA CLAY LOAM

Minnequa clay loam has a 1 or 2 inch surface layer of dark-brown granular clay loam, which breaks into small irregular hard clods. At the surface it forms a rather hard crust, and alkali is present in many places as a white efflorescent mass. The next lower layer, continuous to a depth of 10 or 12 inches, is dark grayish-brown heavy clay loam with white specks of alkali. On exposure it breaks into large irregular clods. It is underlain to a depth of 28 or 30 inches by slightly lighter more grayish-brown material containing numerous spots of lime accumulation. At widely varying depths below 30 inches is partly disintegrated sandy shale, clay shale, or shaly limestone.

The greatest variations in this soil are in the thickness of the soil over the partly decomposed shaly material and in the character of the underlying material. In general the surface soil and subsoil are deepest on the side of areas adjacent to the valley and shallowest on the opposite side. There are, however, narrow strips of more shallow soils extending at right angles to the river valley across the broader areas. The underlying parent material ranges from light-gray rather hard shaly limestone from Timpas Creek eastward to more yellowish softer sandy shale toward the west.

The greater part of this soil is fairly smooth, with a gentle slope toward Arkansas River. Surface drainage is good, but underdrainage is defective on account of the imperviousness of the substratum. Alkali is present in harmful quantities in parts of the soil and is brought to the surface in all seeped areas. Moisture requirements are medium.

Farm crops of the region are grown on this soil, but with only fair or small success, depending on drainage and alkali conditions. The largest areas of the soil occupy the higher uplands on both sides of Timpas Creek south and southwest of Swink and east and southwest of La Junta and occur on the lower-lying areas south and southwest of Huerfano Lake in Pueblo County.

Minnequa clay loam, slope phase.—Minnequa clay loam, slope phase, has a brown or light-brown finely granular 2-inch surface layer slightly crusted on top. Below this is a layer about 6 inches thick of brown clay loam showing a slight tendency to columnar structure, which breaks into rather hard clods about 2 inches through. The next lower layer, which extends to a depth of about 14 inches, is massive yellowish-brown light clay loam which in many places shows white streaks of alkali along root channels and which contains numerous small isolated white specks of gypsum. When dry

and crumbled this layer seems sandy, but when moist it is sticky. Below a depth of 14 inches the subsoil is slightly more yellowish clay loam, and small white specks and some larger spots of lime accumulation are present. At widely varying depths, but at an average of about 30 inches, this rests on the parent material which in the greater part of this region consists of yellowish-brown or pale-yellow soft shale or sandy shale in which are thin beds of light-gray harder shale or shaly limestone. This material contains gypsum and soluble salts in considerable quantities. East of Timpas Creek this harder shaly limestone predominates, and west of that stream the substratum is softer and in places is sandy.

This soil varies more widely than any other in the valley. On nearly level and gently sloping areas the soil has weathered deeply and is fairly productive and easily handled; on the steeper slopes below the small gravel-capped hills and in many places where the underlying material is slightly harder it is shallow and much less productive. Many areas of shallow soil were included in mapping.

This soil occupies the slopes between the river terraces or small stream valleys and the higher adjacent uplands, which in many places have a capping of old stream gravel. On the west side of Huerfano River, 6 miles south of Huerfano Lake, a more nearly level area of shallow soil has been included.

Surface drainage is good or excessive. In many places rain and irrigation water tend to run off before they have time to sink into the soil. Underdrainage, on account of the imperviousness of the underlying material, is very poor. Open ditches are less effective than on soils with open subsoils like the Otero or Rocky Ford soils.

Alkali is present, and wherever the water table is brought near the surface in seeped areas it accumulates in injurious quantities. Moisture requirements are high, because the soil is not sufficiently thick to hold large reserve supplies.

This soil occupies considerable areas along the slopes on the south side of Arkansas River from La Junta to Pueblo. It is used for growing general crops, especially alfalfa and beans.

Minnequa clay loam, shallow phase.—Minnequa clay loam, shallow phase, has a brown or dark-brown medium or finely granular clay loam surface soil, crusted at the surface but loose underneath. Efflorescent alkali is present in many places, together with partly decayed plant roots. This layer is underlain to a depth of 10 or 12 inches by dark-brown or very dark-brown clay loam which breaks into small hard clods from one-sixteenth to one-eighth inch in diameter. Underneath this is light grayish-brown or slightly yellowish-brown heavy clay loam containing whitish specks of gypsum and alkali and underlain at a depth ranging from 24 to 30 inches by yellowish-brown and in places dull-gray partly decomposed shale in which there is considerable gypsum and alkali.

The principal variations are in the thickness of the soil over the parent shale material and in the texture of the surface soil. Areas of heavy clay loam and fine sandy loam have been included in mapping. The parent material also is rather variable.

This soil occurs in association with areas of Minnequa clay in the eastern part of the valley. It occupies very gently sloping areas slightly higher than adjacent areas of Minnequa clay. North of

Canon City an area occupies rather steep slopes at the foot of the mountains. Surface drainage is fair or good, but underdrainage is poor and the soil does not respond readily to artificial drainage.

Alkali is present in the subsoil in many places and in some places has come to the surface in seeped areas. Moisture requirements are not high. Natural vegetation includes salt grass, and where the soil has been cultivated alkali weeds are to be found. The soil is used to some extent for corn, beans, and alfalfa.

Table 11 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and several layers of the subsoil of Minnequa clay loam, slope phase.

TABLE 11.—*Mechanical analysis of Minnequa clay loam, slope phase*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907125	Surface soil, 0 to 2 inches	0.6	2.4	2.6	12.6	33.9	33.6	14.9
4907126	Subsurface soil, 2 to 10 inches	.6	2.0	2.3	12.1	34.6	29.3	19.5
4907127	Subsoil, 10 to 28 inches	.4	2.1	2.4	16.0	24.3	28.3	26.7
4907128	Subsoil, 28 to 54 inches	.6	4.0	2.8	12.4	9.4	20.1	50.9
4907129	Subsoil, 54 to 80 inches	.6	2.4	1.2	4.9	9.6	40.6	40.5

MINNEQUA CLAY

Minnequa clay has a 2-inch surface layer of dark-brown finely granular clay containing considerable organic matter and flocculent alkali. On bare spots it is highly crusted. This layer is underlain to a depth of about 10 or 12 inches by light grayish-brown clay, containing white spots of alkali, which shrinks and breaks into hard irregular clods from one-eighth to one-half inch in diameter. The next lower layer, to an average depth between 20 and 24 inches, consists of pale-yellow, sticky, highly gypsiferous clay. This is underlain by pale yellowish-brown rotten shale very rich in gypsum. In places this shale contains layers of bluish-gray very highly gypsiferous shale.

The material from which this soil has developed differs somewhat from the parent material of most of the soils of this series in containing a higher percentage of clay and gypsum and less fine sand. The very heavy texture of the soil, however, results not only from the nature of the parent material but also from its position on nearly flat and basinlike areas without either good surface drainage or underdrainage.

The principal variations consist of differences in texture and in depth to the parent material. In general, this soil in the lower part of the valley is not so deep as in the western part of the area.

Alkali is present in the surface soil in harmful quantities. Moisture requirements are high. Salt grass constitutes most of the vegetation, and the land is used almost entirely for pasture, for which use it is best suited. The principal areas lie between Wiley and Kreybill. A small area surrounds Huerfano Lake, and others are in the eastern part of the valley north of Holly and near Warwick.

Reclamation of this soil would be much more difficult and slower than of soils with open subsoils.

Table 12 gives the results of mechanical analyses of samples of the surface soil and subsoil of typical Minnequa clay.

TABLE 12.—*Mechanical analysis of Minnequa clay*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907252	Surface soil, 0 to 2 inches	1.0	3.2	2.1	6.4	15.2	36.3	36.1
4907253	Subsoil, 2 to 14 inches	.2	2.2	1.8	5.4	17.2	32.4	41.3
4907254	Subsoil, 14 to 30 inches	.3	1.0	1.0	4.0	16.0	28.9	48.8
4907255	Subsoil, 30 to 60 inches	.6	3.0	2.1	4.5	4.9	31.3	53.5

ORDWAY CLAY LOAM

Ordway clay loam has a dark-brown or very dark-brown finely granular loose clay loam surface layer 2 inches thick. Some coarse sand and small gravel are present and the layer is strongly crusted. The small granules, which are the size of wheat grains and smaller, are angular and hard. The next lower layer, which is 8 inches thick, consists of heavy clay loam of the same color which breaks into hard irregular clods from one-sixteenth to one-fourth inch through. This is underlain to an average depth of about 36 inches by friable light yellowish-brown loam or light clay loam containing considerable fine sand, some small gravel, and a large proportion of gypsum. This material rests on yellowish-brown partly decomposed highly gypsiferous shale which in places is sandy.

The principal variations in this soil are in the depth to which the surface soil has weathered, the percentage of sand and gravel in the subsoil, and the depth to parent shale.

This soil is most extensive north of the Missouri Pacific Railroad, from just east of Sugar City westward to Bob Creek. Areas are nearly level but slope gently toward the south. Surface drainage is fair, but underdrainage is not good. Alkali is present in only small or medium quantities. Moisture requirements are high, owing to shrinking and cracking of the surface soil.

The natural growth on this soil includes shad scale, rabbit brush, buffalo grass, and grama grass. Areas are used largely in the production of alfalfa, sugar beets, corn, small grains, and melons.

Ordway clay loam, shallow phase.—The shallow phase of Ordway clay loam is used to only a small extent for cultivated crops. This shallow soil differs from the typical soil principally in that weathering has taken place to less depth. The soil is slightly lighter grayish brown, and unweathered shale, consisting of grayish-brown, dark grayish-brown, or nearly black shale which effervesces only slightly with hydrochloric acid is reached at an average depth of about 30 inches. In places small hard brown concretions and concretionary fragments are numerous on the surface.

Table 13 gives the results of mechanical analyses of samples of the surface soil, subsurface soil, and subsoil of typical Ordway clay loam.

TABLE 13.—*Mechanical analysis of Ordway clay loam*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907161	Surface soil, 0 to 2 inches	0.8	3.6	2.8	13.6	12.3	38.4	28.4
4907162	Subsurface soil, 2 to 10 inches	5.4	7.4	3.8	13.6	14.8	29.1	26.4
4907163	Subsoil, 10 to 36 inches	2.6	7.2	5.4	25.8	13.4	28.3	17.3
4907164	Subsoil, 36 to 60 inches	.8	4.4	4.4	29.6	14.7	16.9	29.7

ORDWAY CLAY

The surface layer of Ordway clay consists of brown finely granular clay in which the small angular granules are one-sixteenth inch or less in diameter. There is a heavy crust at the surface on the many bare spots. This layer is underlain to a depth of 40 inches by brown or dark olive-brown clay with numerous indefinite light-colored spots, which breaks into hard irregular clods from one-fourth inch to 1 inch in diameter. The next lower layer, which extends to a depth of 8 or 10 feet, consists of slightly more friable clay of the same color.

This soil occupies the lower-lying areas adjacent to areas of Ordway clay loam. A broad strip lies along the north side of Meredith Lake. The soil is derived from the deep weathering of shale and shale outwash. The deeper weathering is the result of poor drainage conditions. The material is uniformly heavy, but in the area near Meredith Lake the shale has been washed over the sandy soil of the Otero series, and the substratum, which is reached at a depth ranging from 3 to 5 feet, is sandy.

Surface drainage of Ordway clay is fair, but owing to the heavy texture of the subsoil underdrainage is slow. Alkali is present in small or medium quantities, but on account of the heavy soil texture is not seriously harmful. Moisture requirements are high.

Ordway clay is used for the production of sugar beets, corn, alfalfa, and small grains. It occupies a rather large part of the area south of the railroad between Sugar City and Ordway, extending westward and northwestward along Bob Creek.

Ordway clay, adobe phase.—Ordway clay, adobe phase, differs from the typical soil in being slightly heavier and further advanced in weathering and in containing slightly more alkali. A strongly crusted deep finely granular mulch lies on the surface of many areas bare of vegetation.

This soil is fairly extensive south and southwest of Meredith Lake. None of it is under cultivation.

Table 14 gives the results of mechanical analyses of samples of the surface soil and subsoil of typical Ordway clay.

TABLE 14.—*Mechanical analysis of Ordway clay*

No.	Description	Fine gravel	Coarse sand	Medium sand	Fine sand	Very fine sand	Silt	Clay
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
4907179	Surface soil, 0 to 3 inches	0.2	0.6	1.8	20.2	18.7	23.3	35.3
4907180	Subsoil, 3 to 15 inches	.0	1.0	1.2	14.1	14.4	27.6	41.8
4907181	Subsoil, 15 to 24 inches	.1	.5	1.2	9.4	11.4	24.8	53.0
4907182	Subsoil, 24 to 36 inches	.0	.8	1.4	10.7	11.6	24.3	51.1

BILLINGS CLAY

The surface layer of Billings clay is brown or olive-brown finely granular material 2 inches thick. It effervesces only slightly with acid and forms a strong crust at the surface. Alkali at the surface is common. This layer is underlain to a depth of 10 or 12 inches by olive-brown heavy clay which breaks into hard clods from one-fourth to one-eighth inch in diameter. The subsoil, which is the next lower layer, is much the same to a depth ranging from 3 to 5 or more feet. It consists of shale outwash, differing only slightly from the parent clay shale from which it is derived. In places it has merely washed down the slope, but in many other places it has been carried down into the valleys of small streams which, in turn, have carried it out into the main river valley. In these valleys and on the fan outwash from them gravel and sand are interstratified with the shale outwash.

The most important variations in this soil are in the depth to which it has weathered and the quantity of organic matter which has been incorporated in it. In places where the soil has weathered rather deeply and has been under cultivation for many years it has become darker in color, has developed a more loamy texture, and has become fairly productive. Such areas are used at Canon City for apple and cherry orchards (pl. 4, A) and for other crops. The natural vegetable growth is largely shad scale and greasewood.

Billings clay occurs along the north side of Arkansas River from Olney Springs to Pueblo and occupies a rather large area east and northeast of Canon City. The soil occupies broad nearly level areas and gentle slopes. Surface drainage is good, but underdrainage, on account of the heavy texture of the soil and the shale substratum, is poor. Alkali is present in moderate quantities and locally in sufficient quantities to be harmful. Moisture requirements, on account of the heavy texture of the soil, are very high. The land is used to some extent in the production of alfalfa and sugar beets. Very little of it is under cultivation.

Billings clay, shallow phase.—Billings clay, shallow phase, has a 2-inch surface layer of brown or olive-brown finely granular clay, slightly crusted at the surface and containing from 10 to 20 per cent of ferruginous sandstone in small pieces. Below this is olive-brown clay, showing slight columnar structure and breaking into hard somewhat regular clods. The next lower material is olive-brown thin-bedded argillaceous shale.

This soil occupies the slopes above the typical soil. It is used to some extent for growing alfalfa and other crops. It is not very productive.

PENROSE LOAM

Penrose loam has a surface layer of light-gray or grayish-brown finely granular loam containing organic matter and small sharp angular fragments of shaly limestone. Below this is a layer, from 8 to 12 inches thick, of light grayish-brown loam containing a small percentage of fragments of shaly limestone. Under cultivation this layer forms large clods which break easily into smaller ones the size of wheat grains. The next lower layer, extending to a depth of about 30 inches, is slightly lighter-brown loam containing more of

the shaly limestone fragments and underlain by the shaly limestone of this region.

The principal variations are the result of differences in the content of rock material and in the depth of the underlying parent rock beds.

This soil occupies a comparatively small area surrounding Penrose. It occurs on nearly level and gently sloping uplands and in broad shallow valleys. Surface drainage is good, but underdrainage, on account of the underlying rock beds, is deficient. Very little alkali is present. On account of the shallowness of the soil, moisture requirements are high.

Penrose loam is used in the production of grain crops, alfalfa, beans, pumpkins for seed, apples, cherries, and berries.

Penrose loam, shallow phase.—Penrose loam, shallow phase, differs from typical Penrose loam in the depth to the underlying rock beds and in the proportion of shaly limestone in the surface soil and subsoil. The depth to rock beds ranges from only 2 or 3 to about 12 inches. In many places in cultivated fields the rocks are turned up by the plow. This phase of soil is practically nonagricultural. In most places it supports a growth of stunted cedars.

In the vicinity of La Junta, shallow shaly loam which occupies part of the upland and the steeper slopes bordering the valleys has been included in mapping.

Penrose loam, heavy phase.—Penrose loam, heavy phase, has a brown or dark grayish-brown heavy finely granular loam surface soil 2 inches thick. This is underlain to a depth of 12 inches by brown or grayish-brown loam or light clay loam, from 5 to 10 per cent of which consists of small sharp limestone fragments. The next lower layer, which extends to a depth of about 30 inches, is lighter-brown light clay loam containing more shale fragments. Where exposed, the surface soil and subsoil form clods, but these are easily broken. Below a depth of 30 or 40 inches is gray shaly limestone, sufficiently soft at the surface to be penetrated by the soil auger. The entire soil effervesces very freely with hydrochloric acid

This soil occupies strips in the lower parts of the small valleys, and on account of the greater depth of the soil and more abundant moisture it is more productive than typical Penrose loam. Some areas have become water-logged through accumulation of irrigation water in the lower parts of the valleys. In the extreme southern part of the area this soil has a covering of silty material, probably wind blown.

This soil is used to a somewhat greater extent for cultivated crops than is the typical soil.

LAS ANIMAS CLAY

Las Animas clay has a 1 or 2 inch dark-brown finely granular surface soil layer. The granules are somewhat angular and are one-half the size of wheat grains. This layer is underlain to a depth of 12 or 15 inches by dark grayish-brown heavy silty clay or clay which shrinks and cracks into large hard clods. The subsoil, which extends to an average depth of nearly 5 feet, is of about the same texture but is slightly lighter brown or grayish brown in color and

grades in the lower part into mottled rust-brown and grayish-brown micaceous silt or fine sandy loam which is underlain by sharp coarse sand and stream gravel.

The texture of the soil, the thickness of the different layers, and the depth to stream gravel differ greatly. In the eastern part of the valley on the north side of the river an included area consists of dark grayish-brown heavy silty clay or clay. On the same side of the river about 4 miles from Lamar is an area of slightly reddish-brown very heavy silty clay or clay, heavier than the average texture of this soil. East, south, and west of Las Animas is the largest area of this soil in the valley. This area is heavy in places, but in others is not extremely heavy or deep. Along the hillside south of Melon it has been modified by the underlying shale. Many lighter-textured areas, consisting of silty clay loam and heavy clay loam, have also been included in mapping.

Many areas of this soil are fairly level, but some, occurring in abandoned river channels, are low and valleylike.

Drainage is poor. Artificial drainage by means of open ditches has been found necessary in many places, but considerable areas are still undrained or poorly drained. Alkali in considerable quantities is present in the greater part of this soil, especially where it is not drained, but it is much less injurious than in a soil of lighter texture. This soil, where drained, is used for growing alfalfa, sugar beets, corn, and small grains. Although it is difficult to handle, it is productive. Areas in which the texture, especially to a depth ranging from 7 to 10 inches, is fairly loamy either because of incorporation of organic matter or addition of soil of lighter texture, are not only easier to cultivate than the extremely heavy areas but are also more productive.

Areas of this soil occur along the valley from the eastern boundary of the surveyed area to Pueblo. In general, the soil occupies the lower-lying and less well-drained positions away from the river channel, but in many places shifting of the channel has brought the river adjacent to areas of this heavy soil.

LAS ANIMAS SILTY CLAY LOAM

The 2-inch surface layer of Las Animas silty clay loam is dark-brown or nearly black finely granular clay loam, which when dry shows a well-defined adobe structure. This material breaks into rather regular fairly easily broken clods 1 or 2 inches in diameter. White alkali extends in streaks along root channels and forms a coating over cleavage planes. The soil becomes heavier with depth and is underlain, at a depth of about 15 inches, by slightly lighter-brown or grayish-brown heavy clay loam containing numerous specks and larger spots of white material, apparently alkali gypsum and possibly lime. Rust-brown and lighter-gray spots also occur in the lower part. At an average depth of about 30 inches this layer is underlain by highly mottled rust-brown and gray silt loam, beneath which is fine sandy loam. Sand and stream gravel lie at widely varying depths but in most places are less than 5 feet deep.

This soil varies widely in the texture of the surface soil and in the depth to the mottled silt and to stream gravel. Few areas of any considerable size are uniform. Low ridges and mounds of shal-

low gravelly soil, as a rule lying at a slightly higher level than adjacent heavier soils, have been included in mapping. Higher-lying areas are commonly shallower and lighter textured than low-lying areas. In general this soil seems to be lighter in the lower part of the valley around Holly than higher up around Rocky Ford. The opposite would be expected. Along the north side of the valley east of Pueblo and in a small area at Canon City wash from Billings clay has been deposited over the stream gravel of the main valley. The surface soil has also been modified by deposits of silt and sand from river overflow and by the incorporation of organic matter through cultivation.

Nearly all this soil is naturally poorly drained, but rather large areas have been drained and are successfully farmed. Others have been recently drained, and still others are undrained and used for grazing purposes only. Moisture requirements are not high, but on account of the high water table maintained by the river and by seepage from the upland alkali has developed and large areas support a growth of salt grass.

Areas of Las Animas silty clay loam are distributed along the valley from Holly to Pueblo. The soil gives good yields of sugar beets, alfalfa, corn, and small grains. It is extensively and successfully used near Pueblo for growing cauliflower and other crops and at Canon City for apple orchards.

LAS ANIMAS CLAY LOAM

Las Animas clay loam differs from the silty clay loam of the same series in being slightly lighter brown in color, lighter in texture, thinner above the sandy and gravelly subsoil, and less uniform in color and texture.

The largest areas of this soil are in the lower part of the valley near Holly. The land is cultivated to only a small extent, principally on account of the alkali present. If well drained it should be productive.

Las Animas clay loam, valley phase.—The valley phase of Las Animas clay loam includes areas in which the deep subsoil is not underlain by heavy beds of stream gravel but by alternating layers of heavy soil and sand and shale material. The 2-inch surface layer is dark grayish-brown finely granulated material. This is underlain by dark grayish-brown heavy clay loam, which shrinks and cracks and in many places contains streaks of white alkali along old root channels and a white deposit along the surface of cleavage planes. On cultivation it breaks into large hard clods. This layer is underlain by lighter-brown heavy clay loam with light-colored spots of lime accumulation. The deep subsoil is more friable and contains thin shale fragments deposited in layers. In places sand and gravel are also present.

This soil is a continuation of Prowers clay loam, poorly drained phase, but is made up to a greater extent of material eroded from the upland. Much of the soil requires artificial drainage. Alkali is present in harmful quantities in undrained areas.

This soil varies principally in the character of the subsoil. In the small valleys from Keesee westward to Kreybill the subsoil is

heavy and seems to be influenced by the shale material from which Minnequa clay has been formed. These areas are for the most part undrained and marshy and contain alkali in considerable quantities. In the small valley near Wiley an area of very heavy brown soil has been included in mapping. This seems to be derived partly from shale but has a thin alluvial covering.

When drained this soil has about the same crop adaptation as the poorly drained phase of Prowers clay loam. As a whole, however, its crop value is lower.

LAS ANIMAS LOAM

Las Animas loam has a 1 or 2 inch surface layer of finely granular dark-brown gritty loam containing an appreciable quantity of coarse sharp sand and fine gravel. The next lower layer, which is from 6 to 10 inches thick, consists of dark-brown heavy coarse-textured loam and is underlain by brown loam continuous to a depth of about 18 inches. The lower part is loose and loamy. The deeper subsoil consists of mottled rust-brown and gray micaceous silt loam or fine sandy loam, underlain by sand and coarse stream gravel at widely varying depths.

The soil lacks uniformity and as mapped includes areas of fine sandy loam and sandy loam, such as those found at Melon and other places, and numerous small areas in which the surface soil is very dark brown and coarse and contains much coarse sharp sand and fine gravel. Most areas of this kind occur as low ridges bordering old stream channels and in many places are too shallow for profitable cultivation. Small gravel mounds and ridges are also included.

The largest continuous bodies of this soil lie west of Las Animas and west of Lamar. Here the soil is fairly productive. Smaller and in most places less productive areas are distributed throughout the valley.

LAS ANIMAS FINE SANDY LOAM

To a depth of about 10 inches, Las Animas fine sandy loam consists of light-brown fine sandy loam which is slightly darker brown at the surface. Below this is slightly heavier fine sandy loam, which becomes heavier with depth but contains alternating layers of fine sand, silt, and clay. At an average depth of about 18 inches this material is underlain by sand, fine sharp gravel, and coarse rounded gravel.

Las Animas fine sandy loam occurs along the river channel from the east boundary of the area to Pueblo. The soil ranges in thickness from only a few inches to 2 or 3 feet and in texture from fine sand to silt. No areas of as much as a few acres extent are even approximately uniform. Recent overflows have made the surface very uneven. The greater part of the soil is shallow and of little agricultural value. It affords little pasturage. A few areas are used for corn and other crops.

Las Animas fine sandy loam, heavy-subsoil phase. -The heavy-subsoil phase of Las Animas fine sandy loam differs from the typical soil in having a subsoil similar to that of Apishapa silty clay loam. Two areas have been mapped near the mouth of Purgatoire River.

Owing to frequent overflow this soil has a rough uneven surface covered with sand ridges and drifted trees and rubbish. At present a large part of it is practically waste land, on which are scattered cottonwood trees. It affords a very little pasturage.

The water table is comparatively high, and sweetclover, once started, would doubtless be able to maintain its hold. It is believed that areas might profitably be cleared, leveled, and seeded to this crop, which could later be supplanted by alfalfa. A second method of reclamation would be more expensive but seems practicable. Arkansas River at all times carries a comparatively high percentage of silt. If low dikes were built to hold this silty water on the land until the silt had been deposited a deep soil might eventually be built up.

On account of the high-water table there is always danger of a surface accumulation of alkali. Where the land is used for pasture, causing the surface soil to pack, this tendency is very greatly increased.

LAS ANIMAS SAND

Las Animas sand is light-brown loose incoherent sand which has been recently deposited by overflow of Arkansas River. It occurs principally in long ridges or strips parallel to the channel and in broader areas of undulating and uneven surface relief. It includes areas of fine sand, sand, and gravel. It has no agricultural value.

LAUREL FINE SANDY LOAM

Laurel fine sandy loam has a dark-brown finely granular fine sandy loam surface layer an inch or two thick, underlain by brown light fine sandy loam containing large quantities of finely divided mica. Below a depth of 12 inches is fine or very fine light-brown micaceous sand which extends to the underlying sand and gravel, reached at a depth ranging from 30 to 48 inches. The depth and character of this lower layer vary widely.

This soil is used at Canon City and Florence for truck crops, mainly lettuce and celery, to both of which it is well suited.

Included with this soil in mapping are areas of silt loam and loam. The included silt loam is dark brown and finely granular at the surface. Below a depth of 1 or 2 inches is dark-brown light silt loam which contains considerable finely divided mica. Under cultivation this material forms clods which are rather easily broken. The second layer, between depths of 12 and 21 inches, consists of dark-brown heavier silt loam containing an appreciable quantity of mica. Between depths of 20 inches and about 3 feet is lighter-brown micaceous light silt loam, fine sandy loam, or very fine sandy loam. The deep subsoil consists of river sand and gravel. On included low terraces the soil is distinctly reddish brown in color. Reddish-brown somewhat more loamy areas have also been included. This soil lacks uniformity in depth and texture. It gives good yields of truck crops and orchard fruits. Small areas extend along the river from Florence to Canon City.

The included loam is dark-brown light loam in which is sufficient coarse sand and fine sharp gravel to give it a rough feel. Between depths of 12 and 30 inches is lighter-brown or grayish-brown light

A, Harvesting cantaloupes grown for seed on Rocky Ford loam, B, field of zinnias on Rocky Ford loam; C, valuable crop of wheat on Rocky Ford loam near Rocky Ford

A, Cherry orchards on Billings clay at Canon City; B, irrigating sugar beets on Manvel silt loam near Granada; C, bank along Apishapa Creek showing profile of Apishapa silty clay loam and typical greasewood vegetation

micaceous loam. This may be underlain by sand and stream gravel or by a layer of grayish-brown very fine sandy loam or silt loam of variable thickness. The next lower material is sand and gravel. This inclusion differs from the silt loam areas principally in containing coarse sand and gravel and in being less uniform in texture and in thickness above the underlying gravel. Some areas need drainage. This soil is used in the same way as the silt loam variation, but it has, as a rule, a lower crop value. It is associated with silt loam and fine sandy loam areas between Florence and Canon City. In the city of Pueblo an area of very gravelly and shallow soil has been included in mapping.

MANVEL SILT LOAM

Manvel silt loam has a surface layer, about 1 inch thick, of finely granular fine sandy loam containing much organic matter and crusting very slightly at the surface. Below this is a layer, from 9 to 12 inches thick, of brown light friable silt loam. The subsoil, extending to a depth of about 30 inches, is light-brown silt loam of medium texture containing a few white spots of lime. The substratum consists of light-brown light silt loam containing no spots of lime.

The principal variations are in texture, depth of the layers, and character of the subsoil. The lighter areas are near the stream by which they were deposited. In the small valleys and on the alluvial fans near the entrance to the main valley this soil is 10 or more feet thick, but at the outer edge of the fans it thins out and is underlain at varying depths by soils of the main valley.

Drainage of a large part of this soil is good, and little alkali is present. Moisture requirements are low. This is one of the most productive soils of this region. Alfalfa, sugar beets, corn, and small grains are grown. (Pl. 4, B.)

MANVEL FINE SANDY LOAM

Manvel fine sandy loam has a brown or dark-brown finely granular light fine sandy loam surface layer underlain at a depth of about 1 inch by brown fine sandy loam which clods slightly under cultivation but breaks down easily. This is about 15 inches thick and is underlain by slightly lighter-brown heavier fine sandy loam which continues to an average depth of 30 inches, where soil of the same color but of lighter texture is reached. The deep subsoil varies greatly.

The principal areas of this soil are near Holly, at Amity, and near Las Animas. Areas occur as broad alluvial fans and low terraces and are nearly level. Along Purgatoire River southeast of Las Animas, a broad nearly level area is separated from a lower-lying more uneven area adjacent to the river by an old poorly drained stream channel. The lower-lying part is unassorted and is little more than river wash.

Drainage, on account of low-lying position and seepage from adjacent higher areas, is not very good, and in places alkali has accumulated in injurious quantities. Moisture requirements are not high. On account of its high content of fine sand, the soil is not

so productive as heavier soils. It is best suited to truck crops and alfalfa.

APISHAPA SILTY CLAY LOAM

The 2-inch surface layer of Apishapa silty clay loam consists of loose granular brown, slightly olive-brown, or grayish-brown clay loam or silty clay loam, heavily crusted at the surface and in places showing accumulations of white alkali. Under this is light olive-brown silty clay loam which is very sticky when wet. When dry it breaks into large irregular clods and shows a few faintly outlined lighter-colored spots. Below a depth of 15 inches the color is very slightly lighter olive brown, and white spots are more numerous and more clearly defined. Below a depth of 30 inches the color and texture are the same, but in places there are thin layers of fine sandy, silty, or fine gravelly material.

This soil has a thickness ranging from 8 to more than 12 feet. It is fairly uniform, the principal variation consisting in the texture of the surface soil, which is in many places lighter near the stream channel, and in the number and thickness of the layers of lighter material in the subsoil. Included strips, mainly adjacent to the stream by which the material was deposited, are of lighter texture than typical to a depth of 8 or 10 inches. These areas are better drained, more easily cultivated, and slightly more productive than the typical soil. In the valley of Huerfano River included areas are slightly lighter textured and more loamy than typical. In such areas there is a reddish or purplish-brown tinge, indicating that the soil has been influenced by material eroded from red sandstone. Such soil contains less alkali than the typical soil and as a whole is more productive. Other included small areas consist of light friable loam.

Apishapa silty clay loam occupies nearly level broad valleys of streams tributary to Arkansas River from La Junta to Pueblo, and areas in the main valley where it has been carried out and deposited by these streams. Drainage is medium or poor, on account of the levelness of the surface and heaviness of the soil material. Alkali is present in moderate or large quantities. Moisture requirements are high. Greasewood grows on much of the soil. (Pl. 4, C.)

This soil is best suited to alfalfa, corn, and sugar beets.

RIVER WASH

River wash consists of unassorted sand and fine gravel, together with a small amount of silt and clay. It occupies low-lying areas slightly higher than the channel of the river at low stage. It is made up of material similar to that found in the deep subsoil of the Las Animas soils. It is of no agricultural value.

AGRICULTURE

The Arkansas Valley area includes irrigated land in six important agricultural counties in Colorado and is one of the most productive irrigated regions of the State.

The value of the more important crops in this region in 1925, as reported by the Colorado Yearbook, is given by counties in Table 15.

TABLE 15.—*Farm values of crops in six counties in Colorado, 1925*

County	Corn	Wheat	Oats	Barley	Beans	Sorghum	Sugar beets	Hay	Miscellaneous
	Dollars	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*	*Dollars*
Prowers	437, 206	450, 839	20, 796	136, 766	12, 852	210, 808	474, 290	884, 437	94, 959
Bent	283, 354	61, 289	12, 634	53, 115	10, 198	155, 618	203, 486	382, 095	180, 634
Crowley	177, 281	10, 175	16, 246	28, 313	47, 846	43, 396	334, 498	305, 295	518, 479
Otero	239, 223	145, 985	82, 162	44, 739	30, 391	28, 523	820, 913	576, 720	1, 391, 453
Pueblo	362, 523	102, 914	37, 149	37, 118	201, 835	50, 521	298, 957	722, 403	480, 523
Fremont	39, 162	19, 602	17, 944	9, 214	2, 302	441		217, 110	213, 953
Total	1, 538, 749	790, 804	186, 931	309, 265	305, 424	489, 307	2, 132, 144	3, 088, 0[illegible]0	2, 880, 001
Grand total									11, 720, 685

Hay, the crop of greatest value in the area, consists largely of alfalfa. Prowers County, at the eastern end of the valley, leads in the production of alfalfa and is closely followed by Pueblo and Otero Counties. Alfalfa, however, is an important crop in the entire area and on practically all soils.

Sugar beets, the crop next in importance, are grown only on irrigated land and to a large extent on the medium or heavy soil types. Otero County is first in the production of sugar beets and Prowers County second.

Corn has been grown in considerable quantities in this region for only a few years. Prowers and Pueblo Counties lead in its production. Prowers County also leads in the production of wheat, producing more than half the wheat grown in the valley.

Sorghum includes several of the nonsaccharine canes. Beans, largely Lima beans, are grown under irrigation, and large dry-farmed areas are devoted to pinto beans. Pueblo is the leading bean-growing county.

Miscellaneous crops include cantaloupes and cucumbers, both for market and for seed, honeydew melons, watermelons, pumpkins, squash, tomatoes, onions, celery, cabbage, cauliflower, lettuce, and a a number of other garden and truck crops. The growing of crops for seed is an important and growing industry. The principal seed crops are cucumbers, cantaloupes, pumpkins, and squash, honeydew melons, watermelons, and flowers, largely zinnias. In the growing of these miscellaneous and seed crops, Otero is the leading county, Crowley County is second, and Pueblo County third.

Table 16, compiled from the Colorado Yearbook, gives the percentage of the cultivated area occupied by the leading crops in 1925.

TABLE 16.—*Percentage of cultivated area devoted to the principal crops in six counties in Colorado, 1925*

County	Corn	Winter wheat	Spring wheat	Oats	Barley	Sorghum	Alfalfa	Sugar beets
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Bent	29. 27	1. 80	0. 63	1. 37	3. 46	33. 21	22. 37	4. 00
Crowley	28. 99	. 33	. 32	2. 98	2. 93	8. 77	28. 84	10. 48
Fremont	15. 68	1. 11	2. 64	15. 99	3. 07	. 32	37. 98	
Otero	15. 42	2. 57	2. 14	5. 16	2. 47	6. 02	31. 79	15. 10
Prowers	21. 95	9. 78	1. 87	1. 32	6. 80	24. 60	24. 45	4. 63
Pueblo	29. 15	3. 50	1. 73	3. 32	2. 32	8. 35	28. 62	4. 23

A striking fact brought out by Table 16 is that though sugar beets are the crop second in value in the area they occupy only a comparatively small percentage of the cultivated area. Sorghum is grown principally on dry land, much of which is not mapped. Oats are extensively grown in Fremont County, where the cooler climate is favorable to the crop.

Table 17, which shows the average number of acres of the principal crops on all farms reporting such crops in 1925, is believed to be fairly representative of all farms included in the soil survey.

TABLE 17.—*Average number of acres of principal crops on farms in six counties in Colorado reporting such crops in 1925*

County	Corn	Oats	Barley	Wheat	Alfalfa
	Acres	*Acres*	*Acres*	*Acres*	*Acres*
Bent	39.38	10.44	15.68	16.68	58.67
Crowley	33.69	14.52	14.75	12.46	36.90
Fremont	9.37	19.64	8.04	5.93	11.83
Otero	15.80	8.90	10.81	11.60	26.83
Prowers	36.42	14.57	23.68	31.97	71.12
Pueblo	27.00	11.31	12.53	13.82	33.44

Table 18 shows the average yield in bushels of corn and wheat for the 5-year period ended with 1925.

TABLE 18.—*Average acre yield of crops in six counties in Colorado for 5-year period ended with 1925*

County	Winter wheat	Spring wheat	Corn	County	Winter wheat	Spring wheat	Corn
	Bushels	*Bushels*	*Bushels*		*Bushels*	*Bushels*	*Bushels*
Bent	28.12	23.78	36.55	Otero	31.69	25.60	37.78
Crowley	26.40	27.22	35.50	Prowers	29.97	24.72	34.95
Fremont	26.66	28.46	35.48	Pueblo	28.88	27.39	35.30

Table 19 shows the average tonnage, the sugar content, and the yield of sugar to the acre for the 13-year period from 1913 to 1925, inclusive, of the large acreage of sugar beets grown by the American Beet Sugar Co.

TABLE 19.—*Average tonnage, sugar content, and yield of sugar per acre from sugar beets grown in three districts in Colorado from 1913 to 1925, inclusive* [1]

District	Tonnage per acre	Sugar content	Sugar per acre
	Tons	*Per cent*	*Pounds*
Lamar	9.84	14.23	2,717
Las Animas	9.92	14.20	2,817
Rocky Ford	10.37	14.75	3,164

[1] Figures from records of the American Beet Sugar Co., Rocky Ford.

The cause of the increase in average acre yield of sugar up the valley from Lamar to Rocky Ford is not definitely known but is believed, in part at least, to be climatic conditions. The compara-

tively cooler climate and possibly the rarer air of the higher altitude may be favorable to high purity. This supposition seems to be borne out by the fact that purity of beets from the San Luis Valley, which has an altitude of 7,500 feet above sea level, is higher even than that of beets produced in the upper part of the Arkansas Valley, where the altitude is about 4,500 feet.

A comparison of the acre sugar yield for the several stations within each of the districts listed shows that in the Lamar district May Valley gave the highest yield 5 years out of 13 and Big Bend and McClave the highest yield for 2 years each. In the Las Animas district Cornelia gave the highest yield 3 years, Lubers 3 years, Melon 2 years, and Fort Lyon 2 years. In the Rocky Ford district, Riley gave the highest yield 5 years, Fowler 3 years, and Pueblo and Avondale 2 years each. The persistence of larger yields of certain stations is believed to be owing, in part at least, to the type of soil on which the beets at those stations are grown.

In the Lamar district beets at May Valley, Big Bend, and McClave are grown largely on the heavier members of the Prowers series. In the Las Animas district, at Cornelia, Lubers, and Fort Lyon, they are grown principally on Fort Lyon clay loam and Fort Lyon loam and at Melon on the heavier Las Animas soils. In the Rocky Ford district at Riley and Fowler they are grown on Rocky Ford soils, some of which have heavy subsoils, and on the Otero soils. At Avondale they are grown on Rocky Ford loam and at Pueblo partly on Minnequa silt loam.

Table 20 shows the acreage of the more important miscellaneous crops grown in the Arkansas Valley in 1925, as reported in the Colorado Yearbook.

TABLE 20.—*Acreage of miscellaneous crops grown in six counties of the Arkansas Valley, Colo., 1925*[1]

County	Cantaloupes for—		Honeydew melons	Watermelons	Pumpkins and squash	Dry onions	Tomatoes	Celery	Cauliflower	Vegetables grown in farm gardens	Cucumbers for—		Alfalfa seed	Broomcorn	Lettuce	Cabbage
	Market	Seed									Pickles	Seed				
Bent	1,062	30	79	13	1	2	4	----	----	----	45	12	----	245	----	----
Crowley	2,289	110	594	185	25	2	80	----	----	----	375	162	225	35	----	3
Fremont	3	100	1	5	650	5	30	35	70	578	15	20	----	----	180	40
Otero	4,143	990	885	180	165	60	750	15	----	263	110	4,190	925	60	----	9
Prowers	1	15	----	10	1	50	----	----	----	112	125	20	146	1,886	----	4
Pueblo	245	340	50	220	140	38	140	95	120	329	130	1,420	8	1	100	130

[1] Since 1925 there has been a very marked increase in the acreage of onions, especially in Otero County, and of cauliflower, especially in Pueblo County.

There is a definite relation between the size of farms and the type of agriculture carried on. Table 21 gives the distribution of farms, according to size, in 1925.

TABLE 21.—*Distribution of various-sized farms in six counties in the Arkansas Valley, Colo., 1925*

County	Less than 3 acres	3 to 10 acres	10 to 20 acres	20 to 50 acres	50 to 100 acres	100 to 175 acres	175 to 260 acres	260 to 500 acres	500 to 1,000 acres	1,000 to 5,000 acres	5,000 acres and over
	No.	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*	*No.*
Prowers	-----	1	2	40	103	286	125	393	89	24	-----
Bent	-----	-----	4	16	41	62	25	286	87	28	-----
Crowley	2	2	65	129	162	22	100	14		-----	-----
Otero	3	30	91	312	369	261	51	43	25	5	1
Pueblo	4	37	132	227	178	262	105	434	188	74	13
Fremont	148	372	123	132	46	58	15	54	50	10	---

In Prowers and Bent Counties, where most of the farms range in size from 260 to 500 acres, the larger tracts are principally dry farmed.

In number of farms of less than 20 acres, the counties rank as follows: Fremont, Pueblo, Otero, Crowley, Bent, and Prowers. This list indicates a geographic progression in the valley from west to east.

Table 22 gives the assessed valuation of farm land, livestock, and poultry and bees.

TABLE 22.—*Assessed valuation of farm property in six counties in Colorado, 1925*

County	Farm land	Livestock	Poultry and bees	County	Farm land	Livestock	Poultry and bees
Prowers	$11, 287, 855	$789, 600	$38, 315	Otero	$11, 229, 755	$776, 615	$55, 140
Bent	6, 443, 125	555, 775	17, 566	Pueblo	9, 993, 375	886, 365	39, 080
Crowley	5, 336, 025	435, 580	18, 120	Fremont	3, 523, 697	389, 425	23, 545

Farming in the Arkansas Valley includes four general types as follows: (1) General farming and stock raising; (2) the growing of special crops combined with some general farming; (3) trucking and market gardening combined with fruit growing and the production of special crops; and (4) fruit growing combined with gardening and seed production.

General farming and stock raising predominate in Prowers and Bent Counties, where the farms are large and the principal crops are alfalfa, sugar beets, corn, and wheat. Many sheep are raised or bought on the market and fattened in the valley. Much of the alfalfa is sold to alfalfa mills, and sugar beets and wheat bring in a large part of the cash income. Some beef cattle are fattened, and a large number of dairy cows supply the local markets.

The growing of special crops in addition to general farming is most prevalent in Otero County, but is carried on in Crowley County on the north and Pueblo on the west. This type of farming depends principally on the growing of highly specialized crops, consisting of sugar beets, cantaloupes for market and for seed, cucumbers for pickles and for seed, beans including a very large acreage of Lima, pinto, and some snap beans, squash and pumpkins, and other seed crops. In 1925 this region grew more than 5,700 acres of cucumbers for seed and more than 1,400 acres of cantaloupes for seed, supplying a large part of the cucumber and cantaloupe seed of

the entire United States. One farmer has for some time grown more than 100 acres of zinnias for seed each year. The production of red clover for seed is at present very profitable but is not extensively practiced. Tomatoes for canning are grown extensively, and the growing of Bermuda onions is increasing in importance. General farming is carried on in conjunction with the growing of these special crops. Poultry raising and beekeeping are important.

Trucking and market gardening, combined with fruit growing and the production of special crops, center around Pueblo, where there are numerous small farms. Many truck crops are grown. Cauliflower for shipping is being profitably grown on heavy Las Animas soils along the north side of the river east of Pueblo and on the Rocky Ford soils on the south side. Cherries are grown commercially on the St. Charles Mesa. General farming, in which sugar beets and alfalfa are important crops, is also practiced. Alfalfa gives high yields. Dairying is important, especially in Pueblo and Otero Counties.

In Fremont County, agriculture centers around fruit growing. The important fruits grown are apples, cherries, pears, peaches, plums, and raspberries. A large area around Penrose is devoted to cherries and other tree fruits and small fruits. Combined with fruit growing, the growing of lettuce, celery, other garden crops, and seed crops is important. Dairying and general farming are carried on to some extent, and considerable income is derived from poultry and bees.

Any soil in this region which is left undisturbed for one season or longer develops at the surface a layer 1 or 2 inches thick of finely granular material. Most soils of the humid regions are deficient in nitrogen, and the cost of supplying this element through use of manures and commercial fertilizers is enormous. In striking contrast, the soils of this region are well supplied with nitrogen. A checking of nitrate determinations made by the nitrate laboratory at Rocky Ford shows that there is a close relation between soil texture and the content of nitrates. More nitrates, both in cultivated and uncultivated soils, are found in the heavier than in the lighter soils.

In much of the humid region lime must be supplied in large quantities if clover and alfalfa are to be grown successfully. In all soils of the Arkansas Valley there is an abundance of lime. Lime is instrumental in maintaining good soil structure and in making drainage and reclamation from alkali easier and more effective.

For a long time it was believed that on account of the newness and fertility of the soils of this region fertilizers were not needed. Manure was not saved, straw and stubble fields were burned over, and the use of commercial fertilizers was ridiculed. During recent years, however, it has been found that manures, well-rotted straw and trash, green crops plowed under, and in certain cases commercial fertilizers rich in phosphate prove beneficial. Extensive experiments have been carried on by the Division of Soil Fertility, Bureau of Chemistry and Soils of the United States Department of Agriculture, and profitable increases in sugar beets obtained with certain fertilizer combinations and on certain soils. Fertilizers rich in phosphate have also proved beneficial to other crops under certain seasonal and soil conditions.

The type of farming carried on has developed gradually and has to a much larger extent than is usual been based on soil differences. Distribution of the special crops depends on markets, size of farms, climatic conditions, and soils. Special crops are grown most profitably on soils of good texture and good underdrainage. Probably 75 per cent or more of the special crops produced are grown on soils of the Rocky Ford series. Success attained in growing seeds and other special crops in Otero and Pueblo Counties is owing very largely to the suitability of these soils for such crops and to favorable climatic conditions. Fruit trees which have lived and borne for a number of years were planted on good soils and have been well cared for. Alfalfa produces best on the better soils, but on account of its fair productiveness, when once it becomes deeply rooted, under adverse conditions, such as shallowness of the soil, presence of alkali, or droughtiness, it is almost universally grown. The same is true to less extent of the sorghums, corn, wheat, barley, and dry beans.

The production of more than $11,500,000 worth of crops each year in the Arkansas Valley is dependent on the soil, water, and climatic conditions. Two of these factors, soil and water, are to a considerable extent under the control of the men who produce the crops. By the correct adjustment of crops to soils, proper management, and the best use of the water available, the value of crops, conservatively estimated, can be increased at least 10 per cent, or more than $1,000,000.

Increased profit in production rather than increased production is now most to be desired. Larger profits can be obtained only by the most careful adjustment of crops to soils, by the maintenance of the soils in good tilth, and by careful regulation of moisture.

As in all other agricultural regions, there is need for better human adjustment. On large areas of high-grade soil, for which water is not available, only a very uncertain type of dry farming can be carried on. In other areas of good soil, seepage and alkali have accumulated until the areas are unproductive. The reclamation of these areas can usually be accomplished only by cooperation of several of the interested landowners. Valuable water used and much labor expended on areas of low-grade land would, if applied to better land, give much larger returns.

IRRIGATION

Rainfall supplements irrigation in the surveyed area, supplying from one-fourth to one-half the amount of moisture used. Although, on account of limited water supply, rainfall is necessary for crop production, at times it proves harmful rather than beneficial to cultivated crops. During the spring and early summer, when water for irrigation is usually most plentiful, there is a tendency toward over-irrigation. As the heaviest rainfall also comes at this time, the soils become saturated, poor in structure, especially if cultivated when too wet, and are able to hold less moisture for plant use than if less had been applied. Beating showers, which cause the soil to become crusted but add little moisture, are also harmful.

In the Arkansas Valley there are 23 large irrigation systems.[2]

[2] Unpublished data supplied by the Colorado Agricultural College and Experiment Station, Fort Collins, Colo.

Crops irrigated in 1922, and the acreage of each, are as follows: Alfalfa, 133,076 acres; cereals, 85,831; sugar beets, 29,973; corn, 25,778; natural grass, 9,700; melons, 6,831; beans, 3,847; orchard fruits, 2,996; market-garden crops, 2,145; and other crops, 19,253.

The acre-feet of water used were as follows: Direct flow, 633,568; storage, 180,048; total, 813,616. Acre-feet to the acre irrigated ranged from 0.86 to 4.73, the average for the entire valley being 2.53 acre-feet to the acre.

These 23 irrigation systems provide for direct flow through main canals and a system of laterals. Several of the systems also have, in addition to the direct flow, storage reservoirs in which water is impounded whenever possible. These reserve supplies have aided very materially in crop production through supplying water during periods when the river is low. During the irrigating season the channel of Arkansas River is often nearly dry.

The cost of irrigation differs among the systems. The following data relative to two of the systems indicates the general range of cost.

The Fort Lyon Canal irrigates 75,000 acres and diverts 229,630 acre-feet. One hundred and forty-four shares of water was originally intended to irrigate each 80 acres of land, but the custom is to use this number of shares for 101 acres. The present assessment is $1.25 a share each year. This covers the cost of maintenance, interest on the bonded debt of $675,000, and retirement of bonds.

The Rocky Ford Ditch irrigates 10,000 acres, the diversion being 45,900 acre-feet or 4.59 acre-feet to the acre. There are 800 shares, the value of one share being 10 acres, but it is the practice to use one share for 12.5 acres. Annual assessments for the last 25 years have been $3.75 a share. When there is not sufficient water to supply all irrigation systems it is prorated.

In a series of records of the number of irrigations and the amount of water used for the different crops, made by the Colorado Agricultural College, it was found that alfalfa and beets receive from 4 to 6 irrigations, corn from 3 to 5, and wheat from 1 to 3. Special crops receive more frequent irrigations, cantaloupes from 4 to 7, cucumbers and onions from 5 to 7, and tomatoes from 5 to 8. The quantity of water used ranged from less than 2 to more than 5 acre-feet an acre, the average being between 2½ and 3 acre-feet. Alfalfa and sugar beets as a rule receive the most water, corn, cantaloupes, cucumbers, and tomatoes less, and small grains the least.

The number of irrigations needed varies with the texture, structure, and thickness of the soil, character of the subsoil, and requirements of the crop to be irrigated.

Sandy soils take water more readily than heavier soils but hold less of it. Heavy clay soils, on the other hand, take water more slowly but hold more of it. In fact, they hold it so tenaciously that it is not readily available to plants. A coarse sandy soil containing 18 per cent water is nearly saturated. A heavy clay containing that percentage of water is, to the plant, dry as dust. Clay soils shrink and crack and so lose much more moisture through evaporation than does a sandy or loamy soil.

The moisture-holding capacity of a soil can be very greatly increased by increasing the supply of organic matter, plowing under manure and green crops, growing deep-rooted crops, and gradually increasing the depth of cultivation. Soils with deep subsoils, like

those of the Prowers, Rocky Ford, and Otero series, also have a much greater capacity and hold larger amounts of moisture in reserve than do soils with shallow subsoils like members of the Minnequa or Penrose series.

For its most effective utilization, water must be applied as needed by both crops and soils. Cultivation of crops should follow irrigation as quickly as possible.

DRAINAGE

Drainage, by means of which surplus water may be carried out of the subsoil, is the necessary accompaniment of irrigation. It might seem that ideal irrigation would consist of applying only the quantity of water which could be taken up by the growing crops or lost from the surface by evaporation. Such a system, even if possible, would not be desirable in the Arkansas Valley because both water and soils contain impurities which must be carried downward and out through drainage water.

Continued use of irrigation water results in the downward movement of the ground water until it reaches an impervious substratum, along the surface of which it moves into the lower-lying areas. If the impervious substratum has but a shallow covering of soil on any part of the slope, seeped areas develop. If soil on the slopes is deep, the surplus water fills the adjacent valley or basin.

In places the impounding of underground water is due to slight displacement and folding of the rock beds. Where this occurs openings through these are necessary to release the ground water.

A saturated surface soil or subsoil excludes the air, and roots of plants cease to function. If the condition is not improved they eventually die.

Success of drainage as well as of irrigation depends on the character of the surface soil and subsoil. Medium and light textured soils are drained more readily than are clay soils. Deep soils with open subsoils can be drained much more successfully than can soils in which there is a heavy layer of lime accumulation, shale, or limestone in the substratum.

In the Arkansas Valley drainage in many places has become necessary and previous to 1924, 26 drainage districts had been organized, 54 miles of main ditch dug, and 98,470 acres drained at an average cost of $14.34 an acre. Many new ditches have been dug since that time. In addition to the areas drained by ditches, considerable areas have been tile drained. The opening of main ditches is the first step in drainage, but in many places this alone is not sufficient. The problems of drainage and reclamation from alkali are inseparable.

ALKALI

The shales underlying the Arkansas Valley and outcropping on the hill slopes which border it are heavily impregnated with soluble salts, a large part of which consists of sodium sulphate, calcium sulphate, and magnesium sulphate, with smaller amounts of sodium chloride. The soluble salt is taken up by the surface water, which flows into the river and its tributaries, and to a much greater extent by all drainage water which percolates through the subsoil and the

shaly substratum. River water as it comes from the mountains is nearly pure, but soon after entering the region where seepage, both direct and from drainage ditches, enters it becomes contaminated with salts. The concentration increases downstream.

Alkali in sufficient amounts to be seriously toxic occurs only in comparatively small areas, all of which can be reclaimed by drainage, flooding, cultivation, and planting to resistant crops. Where the subsoil is fairly open, like that of the Otero soils, the process is neither long nor extremely expensive. It does, however, require the cooperation of landowners. If the surface soil and subsoil are heavy, if the shaly substratum is near the surface and heavily impregnated with alkali, or if a high water table is maintained by the river the difficulty and expense may be too great. The practicability of drainage, therefore, depends on the kind of soil to be drained.

The problems of moisture supply and control, soil structure, both the indirect and toxic effects of alkali, and drainage are so intricately related that each is dependent on the others. Improvement of one condition improves all. Necessary steps include the sparing use of water; checking surface evaporation by cultivation of growing crops; providing drainage outlets and, where necessary, underdrainage; crop rotation in which deep-rooted crops such as alfalfa, clover, sweetclover, and sugar beets alternate with crops which do not root so deeply; and increase in the humus supply by plowing under manure, grain stubble, straw, and green crops.

SOILS

Climatic conditions under which the soils of this region have developed are a normal annual rainfall ranging from 10 to 16 inches, a short grass vegetation, low humidity, bright sunshine, rapid wind movement, and high summer temperature.

Humidity at Denver over a long period of years has averaged 53 per cent, compared with 74 per cent at Kansas City and 78 per cent at San Francisco. The sun shines 67 per cent of the time. The average wind velocity at Las Animas is 7.8 miles an hour, and the normal July temperature at Lamar is 77.8° F.

Under these conditions brown or reddish-brown surface soils have developed. The dark-colored layer is shallow and has a structure somewhat resembling adobe. Lime is abundant, occurring in a shallow well-defined zone of accumulation.

In scientific soil studies, mature soils which have received the full impress of climatic conditions and virgin soils which have not been changed by various treatments which they have received are taken as the standard of comparison.

By mature soils is meant those which have remained in place long enough to have developed distinct layers, due to weathering. The principal characteristics of a mature soil are a dark-colored loamy surface layer, a subsoil layer containing a higher percentage of partly soluble minerals, lime usually predominating, and of heavier texture than the surface soil or the substratum, and a substratum of lighter texture.

The mature soils of this region have three layers, each made up of one or more parts. The upper layer, or A horizon, extends from the surface to a depth ranging from 10 to 15 inches and consists of

the following layers: (1) Dark-brown finely granular slightly crusted soil 1 or 2 inches thick; (2) dark reddish-brown mellow soil from 7 to 9 inches thick, which is not finely granular but shows a tendency to break into somewhat regular masses; and (3) lighter-brown fairly mellow soil about 6 inches thick, which also shows cleavage into slightly regular clods. The second horizon is the same color as the lower part of the first but is heavier in texture and contains an accumulation of lime which may occur as white specks, as well defined white spots, or as a nearly white mass. The columnar or adobe structure is less marked than at the surface. The third horizon is light brown or yellowish brown in color, is lighter in texture than the second, and is free or nearly free from lime accumulation although it is well supplied with lime.

Mature soils develop principally on level or comparatively level areas, because on slopes the surface is eroded or the layers are broken up by erosion and lateral soil movement as rapidly as they are formed. The layers also develop more rapidly in a soil of heavy texture where moisture movement is slow than on light soils where it is rapid.

Mature soils develop wherever like climatic conditions prevail. However, their characteristics depend also on the kind of parent material from which the soils have been derived.

Immature soils are those in which the three well-defined layers have not yet developed. In this region the immature soils consist of the following layers: (1) A thin dark-colored finely granular slightly crusted surface layer 1 or 2 inches thick; (2) a dark-colored less finely granular loamy layer from 6 to 9 inches thick; and (3) a slightly lighter-colored layer. These layers correspond to the A horizon of the mature soils. The B horizon is commonly heavier in texture and in many places contains a concentration of lime, but instead of being underlain by a substratum of lighter texture the parent soil material in much of the Arkansas Valley consists of partly decomposed shale or thin shaly limestone.

Immature soils occur for the most part on slopes where the surface soil is removed by water and wind erosion almost as rapidly as it is formed. There is a constant conflict, therefore, between the forces active in forming mature soils and those by which the surface soil is removed. As a result, the soils remain immature.

Technically, soil material is that from which soil may be formed but which has not yet been changed to soil by climatic conditions. It may be sand bars or dune sand, silty wind-blown loess material, shale outwash, or any other material from which soil can be formed. Soil classification or grouping is based partly on kind of material from which the soil has developed.

In the Arkansas Valley mature soils have developed from (1) silty and sandy wind-blown deposits or loess, (2) old sand and clay deposits, (3) very old high sandy stream and wind deposits, and (4) old alluvial deposits on river terraces or benches. Immature soils have developed from (1) yellow sandy shale, (2) yellowish-brown highly gypsiferous shale, (3) dark olive-brown heavy clay shale, (4) light-gray shaly limestone, and (5) recent stream deposits of two kinds, those in the flood plain of Arkansas River, which have an open sandy and gravelly deep substratum, and those in the valleys of the small streams, which do not have an open gravelly substratum.

Deposits of the river flood plain have been divided into two classes: Those of the lower valley in which the soils of the heavier types are dark brown and carry considerable alkali, and those of the upper valley, which are dark brown or reddish brown and highly micaceous.

Material of the small stream valleys consists of that eroded from the loess and fine sandy slopes of the eastern part of the valley and that which has been eroded largely from the shale hills and slopes farther to the west and modified in places by eroded material from red sandstone.

Mature upland soils in the Arkansas Valley include members of the Prowers series, which were derived from loessial material; soils of the Fort Lyon series, derived from sand and sandy clays; and soils of the Otero series, derived from very old alluvial and possibly wind-blown material. Mature river-terrace soils, which are derived from old alluvial material, have been grouped in the Rocky Ford series. Upland soils developed from residual material and having incompletely developed profiles include members of the Minnequa series, derived from yellowish-brown soft sandy shale; members of the Ordway series, derived from yellowish-brown gypsiferous shale; soils of the Billings series, derived from dark grayish-brown clay shale; and soils of the Penrose series, derived from light-gray shaly limestone. Immature stream-valley soils developed from alluvial material fall in two groups as follows: (1) Those derived from stream deposits and having a gravel substratum, represented by members of the Las Animas series and members of the Laurel series; and (2) soils derived from deposits from small streams and having no gravel substratum, represented by soils of the Manvel series, which were eroded from loess uplands, and soils of the Apishapa series, which were eroded from shale slopes.

SUMMARY

The Arkansas Valley is an important agricultural region. The value of farm crops alone in 1925 was $11,720,685. The important crops are alfalfa, sugar beets, corn, wheat, sorghum, barley, beans, oats, and miscellaneous crops.

Special crops in 1925 had a value of $2,880,001 and consisted of cucumbers, cantaloupes, and other melons, seed crops, truck and garden crops, and fruits.

Successful crop production depends on the supply and distribution of water, maintenance of soil tilth, adjustment of crops to soils, and the concentration of water and labor on the more highly productive soils.

The characteristics of soils of the Arkansas Valley have been determined by climatic conditions and the kind of parent soil material. All soils of the region fall in two broad groups, those in which weathering has produced three well-developed layers or horizons, and those in which weathering has not produced three distinct horizons.

To the first group belong the Prowers soils, developed from loess material; the Fort Lyon soils, developed from old sands and clays and having a very highly developed zone of lime concentration; the Otero soils, developed partly from very old alluvial material on the uplands and having a less highly developed lime horizon; and the

Rocky Ford soils, developed from old alluvial material on river terraces. Most of the more highly productive soils of the region belong to this group. It is doubtful if the highly specialized farming now carried on could have been successfully developed except on such soils.

To the soils of the second group belong those of the Minnequa series, which have come from the weathering of yellowish-brown soft sandy shale; those of the Ordway series, derived from brown highly gypsiferous shale; those of the Billings series, derived from dark-brown clay shales; the Penrose soils, derived from shaly limestone; and the alluvial soils.

The alluvial soils have been further subdivided into soils of the Arkansas River flood plain, in which there is a substratum of sand and gravel, and soils of the small stream valleys which do not have a gravel substratum. The first group of alluvial soils includes the dark-colored, heavy soils of the Las Animas series and the dark sandy micaceous Laurel soils, and the second group embraces the Manvel soils, washed from loess-covered uplands, and the Apishapa soils, where the wash is from shale.

O

[PUBLIC RESOLUTION—No. 9]

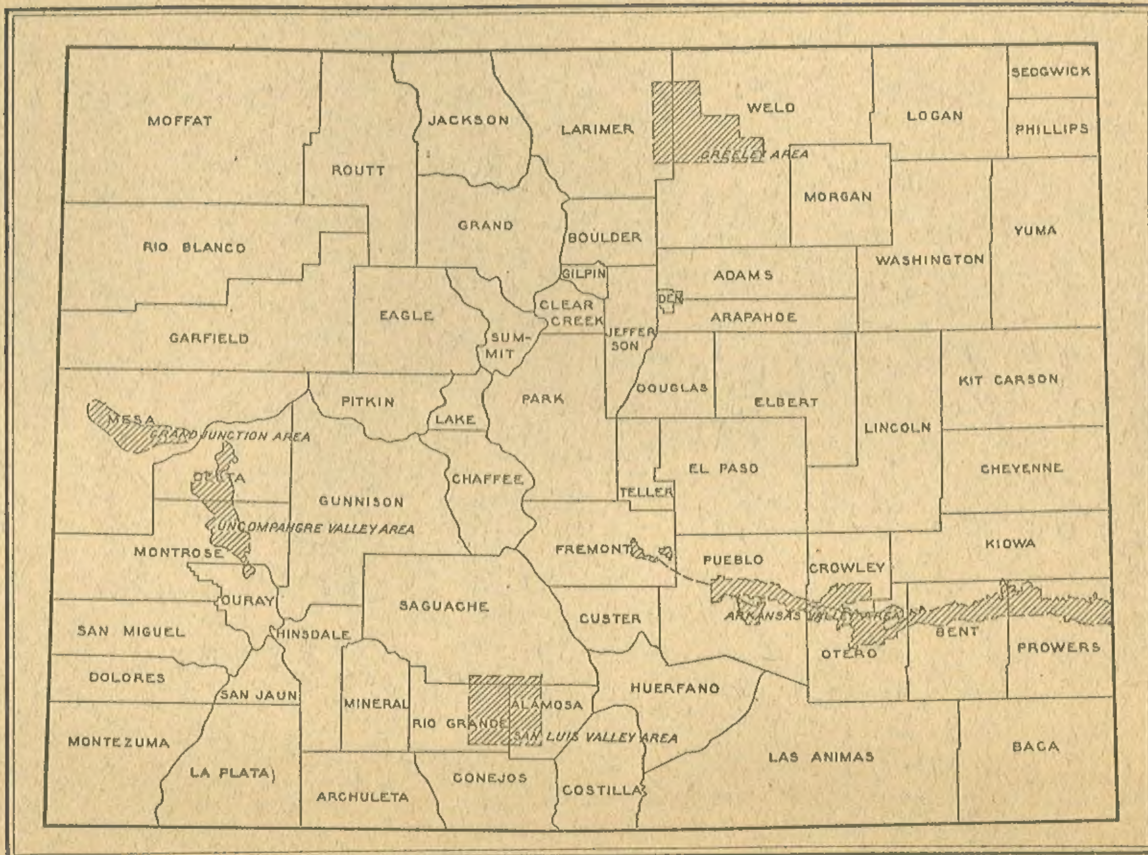
JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 4, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils, and on July 1, 1927, the Bureau of Soils became a unit of the Bureau of Chemistry and Soils.]



Areas surveyed in Colorado, shown by shading

NRCS Accessibility Statement

This document is not accessible by screen-reader software. The Natural Resources Conservation Service (NRCS) is committed to making its information accessible to all of its customers and employees. If you are experiencing accessibility issues and need assistance, please contact our Helpdesk by phone at 1-800-457-3642 or by e-mail at ServiceDesk-FTC@ftc.usda.gov. For assistance with publications that include maps, graphs, or similar forms of information, you may also wish to contact our State or local office. You can locate the correct office and phone number at http://offices.sc.egov.usda.gov/locator/app.

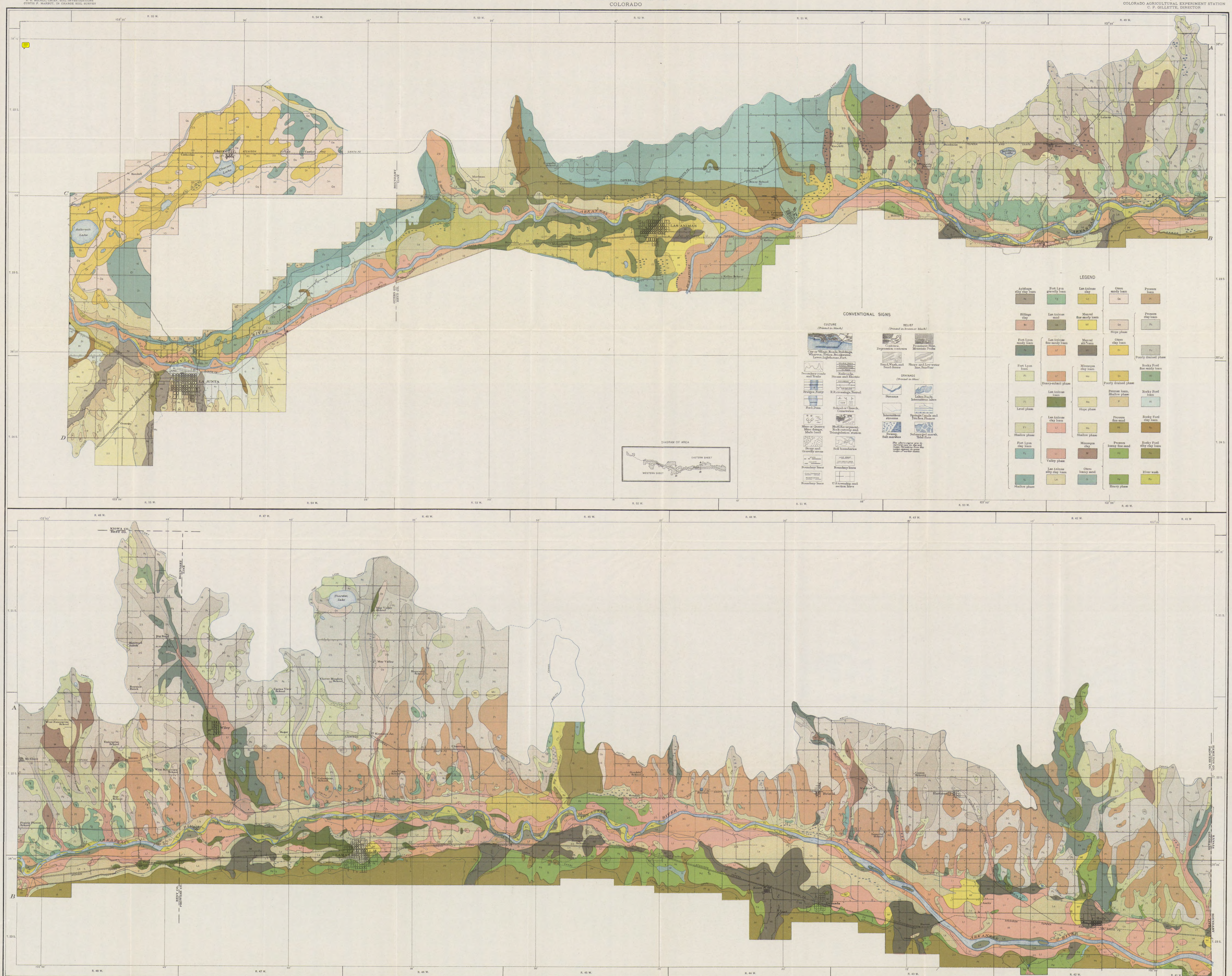
U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP

ARKANSAS VALLEY AREA—EASTERN SHEET

COLORADO

COLORADO AGRICULTURAL EXPERIMENT STATION
C. P. GILLETTE, DIRECTOR



Soils surveyed by A. T. Sweet, U. S. Department of Agriculture, in charge, and Wayne Inman, Colorado Agricultural Experiment Station

U. S. DEPARTMENT OF AGRICULTURE
BUREAU OF CHEMISTRY AND SOILS
HENRY G. KNIGHT, CHIEF
A. G. McCALL, CHIEF, SOIL INVESTIGATIONS
CURTIS F. MARBUT, IN CHARGE SOIL SURVEY

SOIL MAP

ARKANSAS VALLEY AREA—WESTERN SHEET
COLORADO

COLORADO AGRICULTURAL EXPERIMENT STATION
C. P. GILLETTE, DIRECTOR

Soils surveyed by A. T. Sweet, U. S. Department of Agriculture, in charge, and Wayne Inman, Colorado Agricultural Experiment Station.

1 ½ 0 1 2 3 4 Miles
Scale 1 inch-1 mile

Field Operations
Bureau of Soils
1926